



Reflection on Tournament of  
Towns Summer Conference 2015... 10

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# CMS NOTES de la SMC

March/April  
mars/avril  
2016

## Vice-President's Notes / Notes du Vice-président

**Raj Srinivasan, (University of Saskatchewan)**  
Vice-President – West / Vice-président – Ouest

## Lecture Capture Model to Enhance Student's Learning



A debate is brewing over the merits and demerits of the classroom versus the online teaching of mathematics. However, there may be a middle ground, one that may incorporate the benefits of both teaching methods—the Lecture Capture Model.

In the December 2015 issue of *CMS Notes*, Rahim Moosa argued in defense of the classroom structure and against the online delivery of math courses. As he noted, mathematics is an intelligent discipline with complex ideas and the majority of students require detailed explanation and extensive math help from instructors before they are able to grasp the complexities of the subject. These facilities however, are lacking in online math courses where little interaction exists between the student and the instructor. As such, he contends, the online model is not appropriate for math teaching. I concur with this observation.

I will add further that mathematics is not like a spectator sport. For students to be successful in this field, they have to be actively involved in the learning process. For example, in addition to attending lectures in the classroom, they are expected to practice numerous exercises on their own and to be proactive in seeking help from instructors, tutorial assistants or math help centers for the topics and concepts with which they are

## L'Enregistrement de cours en classe afin d'améliorer l'apprentissage des étudiants

Un débat semble se préparer autour des avantages et désavantages de l'apprentissage en classe en opposition à un apprentissage des mathématiques en ligne. Néanmoins, il pourrait y avoir un terrain d'entente qui incorporerait les bénéfices des deux méthodes d'enseignement – la Méthode d'enregistrement de cours.

Dans le numéro des *Notes de la SMC* de décembre 2015, Rahim Moosa argumentait en faveur de la structure actuelle des salles de classe et contre l'enseignement des mathématiques en ligne. Comme il le notait, les mathématiques sont une discipline intelligente possédant des idées complexes et la majorité des étudiants requièrent des explications détaillées et une aide importante de la part de leurs instructeurs avant qu'ils ne puissent saisir les complexités du sujet. Ces aides sont cependant absentes des cours en ligne de math où peu d'interaction entre l'instructeur et ses étudiants est disponible. Ainsi, il affirme que le modèle en ligne n'est pas approprié à l'enseignement des mathématiques. J'appuie cette détaillée.

J'ajouterais même que les mathématiques ne sont pas comme les sports spectaculaires. Pour que les étudiants réussissent dans ce domaine, ils doivent être impliqués activement dans le processus d'apprentissage, par exemple, en plus d'être présents au cours en classe, il est attendu de leur part de pratiquer

## Why Do We Want To Know?

**Robert Dawson**, Department of Mathematics and Computer Science, Saint Mary's University



Most scientists eat what's put in front of them. Not literally, of course, but they study what exists in nature. By and large, entomologists study bugs that actually exist, and chemists content themselves with the elements that are in the periodical table along with the compounds that they form. Physicists (who share some of our eccentricities) sometimes consider phenomena that are neither observed nor required by theory, and ask "what if?". Magnetic monopoles form one famous example. Another instance, now rather discounted, is "Davis mechanics": a hypothetical alternative to Newtonian mechanics in which the second law of motion involves higher derivatives of position as well as acceleration. (Names for these higher derivatives have not been fully standardized, but  $x^{(n)}$ , for  $n = 3 \dots 5$ , have sometimes been called "jerk," "jounce," and "snap," a sequence jocularly extended by "crackle" and "pop.") Had nature worked this way, it might have made reactionless space drives possible. However, somebody once told me that it would also have made atoms unstable. We're probably better off with Newton.

Mathematics, of course, is a game that we make up as we go along, and making up the questions is half the fun. Some of the questions are serious - the Poincaré conjecture, for instance, was a very obvious question that once asked demanded an answer. Some are deliberately frivolous: Conway's "thrackle conjecture", that a graph, embedded in the plane so that every pair of edges meet exactly once, can have at most twice as many edges as vertices, seems like a carefully constructed excuse for doodling – but it has remained unsolved for more than half a century.

But what of the cases in between? Where do we put Goldbach's conjecture? Fermat's "last theorem"? And what about the infamous Collatz  $3n + 1$  conjecture; frivolous solitaire game or cutting edge theory of computation? The Riemann hypothesis seems like flogging a horse already killed and buried by experiment, but its implications are wide-ranging and profound.

There are no silly questions.

### Correction

In our Member Profile of Patrick Ingram (page 15, CMS Notes: Volume 48 No.1, February 2016), his surname was mis-spelled.

Patrick, please accept our apologies.

## Pourquoi voulons-nous savoir ?

La plupart des scientifiques mangent ce qu'on leur présente. Pas littéralement, bien sûr, mais ils étudient ce qui existe dans la nature. En général, les entomologistes étudient les insectes qui existent réellement, et les chimistes se contentent des éléments du tableau périodique et des composés que forment ces éléments.

Il arrive toutefois que les physiciens (qui ont en commun certaines de nos excentricités) étudient des phénomènes qui ne sont ni observables ni requis par la théorie, et posent la question : « que se passerait-il si...? ». L'exemple célèbre des monopôles magnétiques appartient à cette catégorie, tout comme celui, qui n'a plus tellement cours aujourd'hui, de la « mécanique de Davis », une alternative hypothétique à la mécanique newtonienne dans laquelle la deuxième loi de Newton impliquerait des dérivées supérieures en termes de position et d'accélération. (Les noms de ces dérivées n'ont pas été entièrement standardisés, mais  $x^{(n)}$ , pour  $n = 3 \dots 5$ , ont parfois été appelées en anglais jerk, jounce et snap, séquence parfois suivie, à la blague, de crackle et pop, en référence au slogan des Rice Krispies [snap, crackle, pop ou cric, crac, croc en français]). Or, si la nature avait fonctionné ainsi, la propulsion spatiale sans réaction serait possible. Mais quelqu'un m'a aussi dit un jour que cela rendrait également nos atomes instables. Il vaut sans doute mieux s'en tenir à Newton.

Les mathématiques, bien sûr, sont un jeu que nous créons en jouant, et imaginer les questions compte pour la moitié du plaisir. Certaines questions sont sérieuses, comme la conjecture de Poincaré, à laquelle il fallait évidemment trouver une réponse à l'époque. Et certaines sont délibérément frivoles, par exemple la « conjecture thrackle » de Conway selon laquelle un graphe est représenté sur un plan de sorte que chaque paire d'arêtes ne se croise qu'une seule fois et a au maximum deux fois plus d'arêtes que de noeuds. Cette conjecture, qui semble s'apparenter davantage à un savant prétexte pour gribouiller, n'est pourtant toujours pas résolue après plus d'un demi-siècle.

Mais que faire des cas qui se situent entre ces deux extrêmes ? Où plaçons-nous la conjecture de Goldbach ? Ou le « dernier théorème » de Fermat ? Et que faire de la célèbre conjecture  $3n + 1$  de Collatz ? Est-ce un jeu frivole de solitaire ou un exemple ultra pointu appartenant à la théorie du calcul ? Quant à l'hypothèse de Riemann, certains pourraient penser que compte tenu de tous les calculs réalisés pour la valider, l'exercice est une vraie perte de temps; pourtant, ses implications sont profondes et de longue portée.

Aucune question n'est absurde.

### Correction

Dans la section Profile membre de la SMC : Patrick Ingram (page 15, Notes de la SMC: Tome 48, numéro 1, février 2016), son nom de famille était mal orthographié.

Patrick, nous sommes désolés.

## CMS Welcomes Back Graham!

**I**t is with great pleasure that we announce that Graham Wright (retired) has accepted a new role with the CMS as Interim Executive Secretary effective now until the end of December 2016.

As the CMS looks to re-assess its future directions, Graham will assist in its transition. He was the Executive Director of the CMS for over thirty years before his retirement in 2009 and with his past experience; we are in good hands to ensure CMS' future success. Welcome Back Graham!

## La SMC annonce le retour de Graham !

**C**'est avec grand plaisir que nous annonçons le retour de Graham Wright (retraité) comme secrétaire exécutif intérimaire de la SMC, rôle qu'il assumera jusqu'à la fin décembre 2016.

Graham sera d'une grande aide pour notre réévaluation des directions futures de la SMC, grâce à son expérience de plus de 30 ans comme directeur exécutif de la SMC, ce jusqu'en 2009 quand il a pris sa retraite. Nous sommes en de bonnes mains pour assurer le succès futur de la SMC. Merci Graham !



### NOTES DE LA SMC

Les Notes de la SMC sont publiés par la Société mathématique du Canada (SMC) six fois par année (février, mars/avril, juin, septembre, octobre/novembre et décembre).

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Les Notes de la SMC, les rédacteurs et la SMC ne peuvent pas être tenus responsables des opinions exprimées par les auteurs.

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La Société mathématique du Canada appuie l'avancement, la découverte, l'apprentissage et l'application des mathématiques. L'exécutif de la SMC encourage les questions, commentaires et suggestions des membres de la SMC et de la communauté.

### CMS NOTES

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The CMS promotes the advancement, discovery, learning and application of mathematics. The CMS Executive welcomes queries, comments and suggestions from CMS members and the community.

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The Calendar brings current and upcoming domestic and select international mathematical sciences and education events to the attention of the CMS readership. Comments, suggestions, and submissions are welcome.

**Denise Charron**, Canadian Mathematical Society,  
 (managing-editor@cms.math.ca)

Le calendrier annonce aux lecteurs de la SMC les activités en cours et à venir, sur la scène pancanadienne et internationale, dans les domaines des mathématiques et de l'enseignement des mathématiques. Vos commentaires, suggestions et propositions sont le bienvenue.

**Denise Charron**, Société mathématique du Canada  
 (redacteur-gerant@smc.math.ca)



## MARCH 2016 MARS

- 13-18 CANSSI Improving the Quantitative Interpretation of Simulation Models, BIRS, Banff, Alta.
- 18 PIMS/ UBC Distinguished Colloquium: Jacob Lurie, University of British Columbia, Vancouver, B.C.
- 18-22 CRM Nirenberg Lectures in Geometric Analysis at the CRM: Gunther Uhlmann (University of Washington), Montreal, Que.

## MAY 2016 MAI

- 9-13 GIREF Workshop: Applications and New Frontiers for the Finite Element Method, Université Laval, Québec City, Que.
- 12-24 MBI Summer School on Mathematical Epidemiology, Mathematical Biosciences Institute, Columbus, Ohio
- 16-20 AARMS/FIELDS Workshop on Homotopy Type Theory, Fields Institute, Toronto, Ont.
- 16-20 FIELDS Conference on Qualitative aspects of the theory of nonlocal Equations, Fields Institute, Toronto, Ont.
- 16-20 CRM Workshop: New Challenges for the Calculus of Variations Stemming From Problems in the Materials Sciences and Image Processing, Montreal, Que.
- 29-31 CSHPM 2016 Annual Meeting, University of Calgary, Calgary, Alta.
- 29-Jun 1 FIELDS Workshop on Dynamical Systems and Operator Algebras, University of Ottawa, Ont.
- 30-Jun 1 CORS 2016 Annual Conference, Banff, Alta.
- 30-Jun 11 2016 Séminaire de Mathématiques Supérieures: Dynamics of Biological Systems, University of Alberta, Edmonton, Alta.

## JUNE 2016 JUIN

- 2-4 FIELDS Workshop on Nonlinear Optimization Algorithms and Industrial Applications, Fields Institute, Toronto, Ont.
- 3-7 CMESG (Canadian Mathematics Education Study Group) Conference, Queen's University, Kingston, Ont.
- 6-10 FIELDS Conference on Recent Trends on Elliptic Nonlocal Equations, Fields Institute, Toronto, Ont.
- 13-16 FIELDS Conference on Geometry, Algebra, Number Theory, and their Information Technology Applications (GANITA), Fields Institute, Toronto, Ont.
- 13-17 PIMS Workshop on Nonlocal Variational Problems and PDEs, University of British Columbia, Vancouver, B.C.
- 19-22 FIELDS Workshop on Mathematics in the Time of Mathematics Open Online Communities (MOOCs), Fields Institute, Toronto, Ont.
- 20-30 CRM Workshop: Partial Order in Materials: Analysis, Simulations and Beyond, Montreal, Que.

- 24-27** 2016 CMS Summer Meeting / Réunion d'été de la SMC 2016, University of Alberta, Edmonton, Alta.

- 26-30** CAIMS 2016 Annual Meeting, University of Alberta, Edmonton, Alta.

## JULY 2016 JUILLET

- 3-9** CRM 12<sup>th</sup> International Conference on Symmetries and Integrability of Difference Equations (SIDE12), Hotel Le Chantecler, Sainte-Adèle, Que.
- 4-8** CRM Workshop: Complex Boundary and Interface Problems: Theoretical models, Applications and Mathematical Challenges, Montreal, Que.
- 4-8** Formal Power Series and Algebraic Combinatorics, Simon Fraser University, Vancouver, B.C.
- 4-14** CRM Summer School: Spectral Theory and Applications, Université Laval, Québec City, Que.
- 11-15** FIELDS World Congress of Probability and Statistics, Fields Institute, Toronto, Ont.
- 11-Aug 5** 2016 AARMS Summer School: Applications of Category Theory, Combinatorics and Number Theory, Information: [aarms.math.ca/the-2016-aarms-summer-school](http://aarms.math.ca/the-2016-aarms-summer-school). Apply by March 15<sup>th</sup>.
- 18-22** CRM Workshop: Computational Optimal Transportation, Montreal, Que.
- 18-22** Conference on Geometry, Representation Theory and the Baum-Connes Conjecture, Fields Institute, Toronto, Ont.
- 18-22** EMS 7<sup>th</sup> European Congress of Mathematics, Technische Universität Berlin, Berlin, Germany
- 19** PIMS Marsden Memorial Lecture: The Constraint Manifold of General Relativity (Richard Schoen), BIRS, Banff, AB <http://www.pims.math.ca/scientific-event/160719-pmmlrs>
- 24-31** International Commission on Mathematical Instruction (ICME-13), U of Hamburg, Hamburg, Germany
- 25-28** New Trends in Approximation Theory: A Conference in Memory of André Boivin, Fields Institute, Toronto, Ont.
- 27-Aug 5** PIMS Summer School and Workshop on Geometric and Topological Aspects of the Representation Theory of Finite Groups, University of British Columbia, Vancouver, B.C.

## AUGUST 2016 AOÛT

- 3-6** MAA MathFest 2016, Columbus, Ohio
- 15-19** FIELDS 2016 Industrial Problem Solving Workshop, Fields Institute, Toronto, Ont.
- 15-26** Two Weeks in Vancouver - A Summer School for Women in Math, University of British Columbia, Vancouver, B.C.
- 21-26** 24th International Congress of Theoretical and Applied Mechanics (ICTAM 2016), Palais des congrès, Montreal, Que.
- 22-26** FIELDS/CRM Conference on Methods of Modern Mathematical Physics, Fields Institute, Toronto, Ont.
- 28-Sep 1** CRM/FIELDS Frontiers in Mathematical Physics, CRM, Montreal, Que.

## IMO Send-Off Reception

Mark June 26th in your calendars!

(We are aware that this date conflicts with the 2016 CMS Summer Meeting in Edmonton but it was unavoidable. If you will be in Toronto on June 26th, please consider this great opportunity.)

The CMS is sponsoring an IMO Send-Off Reception for Canada's IMO Team on June 26th, at York University, Executive Learning Centre, Schulich School of Business, 4700 Keele Street (56 Fine Arts Rd), Toronto. The reception will begin at 5:30 p.m. (ticket price TBD); seats are limited.

Join the CMS in celebrating the occasion! Following the Send-Off, Canada's IMO Team will travel to BIRS to train and then on to Hong Kong for the IMO competition (July 6-16, 2016). Last year, Canada placed 9th out of 104 countries and one member of the team, Alex Song, was ranked #1 IMO competitor with a perfect score!

The program planned for this memorable evening is underway and invited speakers, *yet to be confirmed*, include the Right Honourable Justin Trudeau (Prime Minister), Kristy Duncan (Minister of Science), Liz Sandal (Minister of Education), and other dignitaries. Please visit our IMO page frequently at <http://funding.cms.math.ca/http-funding-cms-math-ca-en-ca/mathcamps-e/23-imobanquete> for more details as they are available! All members of previous Canadian IMO teams will be invited to participate; the last IMO Team Reunion was held in June 2000.

Details are forthcoming!

## Réception de lancement de l'OIM

Marquez le 26 juin à vos calendriers !

(Nous savons que cette date rentre en conflit avec la Réunion d'été 2016 de la SMC à Edmonton mais c'était inévitable. Si vous deviez être à Toronto le 26 juin, veuillez prendre en considération cette opportunité excellente).

La SMC commandite la Réception de lancement de l'OIM pour l'équipe canadienne de l'OIM, le 26 juin, à l'Université York, Executive Learning Centre, Schulich School of Business, 4700 Keele Street (56 Fine Arts Rd), Toronto. La réception commencera à 17h30 (les prix des billets seront annoncés) ; le nombre de places est restreint.

Joignez-vous à la SMC afin de fêter cette occasion ! Après le lancement, l'équipe canadienne de l'OIM voyagera à BIRS pour entraîner et ensuite à Hong Kong pour l'OIM (du 6 au 16 juin 2016). L'année dernière, le Canada s'était placé 9<sup>e</sup> sur 104 pays et un membre de l'équipe, Alex Song, se classa premier compétiteur de l'OIM, obtenant un score parfait !

Le programme prévu pour cette soirée mémorable est en cours de rédaction et les conférenciers invités, *à confirmer*, incluent le très honorable Justin Trudeau (Premier ministre), Kristy Duncan (Ministre des sciences), Liz Sandal (Ministre de l'éducation) ainsi que d'autres dignitaires. Veuillez consulter notre page de l'OIM fréquemment à cette adresse : <http://funding.cms.math.ca/http-funding-cms-math-ca-fr-ca/> pour plus de détails au fur et à mesure qu'ils sont ajoutés ! Tous les membres des équipes canadiennes précédentes de l'OIM sont invités à participer ; la dernière réunion d'équipe de l'OIM fut tenue en juin 2000.

Les détails sont à suivre !



## *Continued from cover*

having difficulty grasping. This is the principle behind the classroom teaching format, but it is not always realized in practice.

Experience has shown that many students have difficulty with fully understanding the materials covered in the class. This is not surprising, as often some concepts are introduced in just 10 or 15 minutes during the lecture. However, despite having difficulties with understanding, why do so few students actually seek assistance from the instructors, the tutorial assistants or math help centers? Given this context then, is it not of benefit to have an alternative model that students may find more appealing and one which they are likely to make use of at their convenience?

Why not use the available technology to enhance the learning outcomes for the students? I am not referring to fancy PowerPoint presentations with colourful graphics or gadgets such as clickers or entertainment media such as lively videos, but rather Lecture Capture! Lecture Capture has the advantage of preserving the in-class lecture as well as helping students to access the instructor's lecture at anytime and anywhere!! The technology is very simple (most universities have it); instead of using the chalk and blackboard, the instructor uses a tablet, for example, Smart Sympodia, and a video capture system such as Echo360. In the classroom, the lecture is projected onto the screen so that the students in the room have full access to it, and all the instructor's verbal and written comments are captured in a video which is subsequently made available to the student.

The Lecture Capture Method has many virtues to recommend it. Firstly, students in the classroom do not have to take notes or copy the lecture verbatim in order to understand it; they can, instead, focus on the ideas being presented. The lecture will be available to them in its entirety outside of the classroom, and they may listen to it as many times as they need, and according to their individual schedules. Students have the advantage of learning at their own pace. They can review complex materials repeatedly and review lectures before examination; this is the opposite of passive learning—a concern with the online delivery method. Also in this scenario, there is no need, or very reduced need, for secondary help in the form of teaching assistants or math help centres—resources which students were not accessing anyway.

Lecture Capture is also helpful to instructors. It gives them the opportunity to polish, revise or modify their presentation the next time they offer the course. As an instructor, ask yourself this: when was the last time you actually listened to your presentation? Lecture Capture gives you this option and you can use it to improve your previous performance. In other words, you can do auto critiques of your classroom performance on a regular basis and work to refine it.

Admittedly, there are concerns about the Lecture Capture format. One issue raised is that the format will replace the in-class teaching. The biggest fear among faculty is that Lecture Capture will render them irrelevant. The exact opposite is true. Lecture Capture allows

instructors to be more engaged in their presentation and to better understand the learning needs of all students. Because students are not preoccupied with note-taking, they are free to interact with the instructor and to better communicate to him/her where more in-depth explanations or clarifications are necessary to augment their learning. The instructor's role remains critical.

Furthermore, lectures done via this medium are not open access; they are limited to only the students in the particular class and access is password protected. Hence, the lecture remains the intellectual property of the instructor.

Some worry too that students may not come to the class if access to the lecture materials is provided to them 24/7. So what if some students miss the class or not come to lectures at all? At the university level, should we really care about attendance? What guarantees do we have that students learn when they actually come to the class? Good lecturers will always draw students to their class even if the lecture was captured. And with access to the lecture materials, students have the option of choosing the in-class lecture or the Lecture Capture format, or both.

Given that our class sizes are getting larger and larger, and it is unrealistic to have interactions in larger classrooms and, more importantly, that the subject of math is complex, Lecture Capture offers a way of addressing this dilemma. If students choose not to come to class because they are comfortable with just the Lecture Capture, this reduces the numbers in the classroom and allows for greater student-teacher interactions with the students who do attend the in-class presentation.

Given the many advantages of Lecture Capture Method, let's expand the use of this technology in our classrooms without being overly concerned about the shift away from the traditional ways of teaching and learning. The times are changing (or have changed)! To keep math education vibrant and appealing to students, we need to change with it.



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## *Suite de la couverture*

de nombreux exercices de leur côté et d'être proactifs lorsqu'ils rencontrent des difficultés avec des concepts ou sujets, afin de demander de l'aide de la part de leurs instructeurs, chargés de cours ou des centres d'aide en math. C'est le principe sous-jacent au format d'enseignement en classe, mais il n'est pas toujours réalisé en pratique.

L'expérience nous a démontré que de nombreux étudiants avaient des difficultés à comprendre pleinement le matériel couvert en classe. Ce n'est pas surprenant étant donné que certains concepts sont souvent introduits en 10 ou 15 minutes durant les cours en salle. Cependant, malgré les difficultés de compréhension, pourquoi si peu d'étudiants recherchent-ils activement de l'aide de la part de leurs professeurs, chargés de cours ou des centres d'aide en math ? Compte tenu de ce contexte, ne serait-il pas bénéfique d'avoir un modèle alternatif que les étudiants puissent trouver plus attrayant et qu'ils utiliseraient davantage à leur convenance ?

Pourquoi ne pas utiliser la technologie disponible afin d'améliorer les résultats des étudiants et de leurs apprentissages ? Je ne me réfère pas à des présentations PowerPoint sophistiquées contenant des graphiques bariolées, des gadgets tels que des télécommandes ou des outils de divertissements comme des vidéos entraînantes mais plutôt à l'Enregistrement de cours en classe ! L'Enregistrement de cours en classe a l'avantage de préserver les leçons données en classe ainsi que d'aider les étudiants à accéder aux cours de leur instructeur à n'importe quel moment et peu importe où ils se trouvent ! Les technologies nécessaires sont très simples (la plupart des universités sont déjà équipées), au lieu d'utiliser la craie et le tableau noir, l'instructeur utilise une tablette. Par exemple, la Smart Sympodia et un système d'enregistrement vidéo tel que l'Echo360. En classe, la leçon est projetée sur l'écran pour que les étudiants en salle aient pleinement accès à celle-ci et tous les commentaires verbaux ou écrits sont capturés dans la vidéo qui sera disponible pour les étudiants par après.

La Méthode d'enregistrement de cours a assez de vertus pour que je la recommande. Tout d'abord, les étudiants en classe n'ont pas à prendre de notes ou recopier la leçon verbatim afin de la comprendre, ils peuvent, à la place, se concentrer sur les idées qui leurs sont présentées. Le cours leur sera disponible dans son entièreté hors de la classe et ils peuvent l'écouter autant de fois qu'ils le souhaitent, selon leur horaire individuel. Les étudiants ont l'avantage d'apprendre à leur propre rythme. Ils peuvent réviser le matériel compliqué de manière itérative et réviser les cours avant leur examen ; tout est à l'opposé de l'apprentissage passif – un élément inquiétant inhérent à la méthode d'enseignement en ligne. Dans ce scénario, le besoin d'avoir recours à des enseignants, des chargés de cours ou des centres d'aide à fin de demander de l'aide, est grandement réduit, ou presque réduit à zéro – ressources que les étudiants n'allait pas chercher dans tous les cas.

L'Enregistrement de cours est aussi utile aux enseignants. Il leur donne l'opportunité de polir, réviser ou modifier leur présentation la prochaine fois qu'ils offrent ce cours. En tant qu'enseignant,

demandez-vous ceci : quelle fut la dernière fois que vous avez écouté votre leçon ? L'Enregistrement de cours vous donne cette option et vous pouvez l'utiliser afin d'améliorer votre performance précédente. En d'autres mots, vous pouvez auto-critiquer vos présentations de cours de manière régulière et travailler afin de les améliorer.

Il est vrai que certaines inquiétudes pèsent sur l'Enregistrement de cours. Une de celle-ci est que cette méthode remplacera l'enseignement en classe. La plus grande peur parmi les universitaires est que l'Enregistrement de cours les rendra obsolètes. C'est l'exact opposé qui est vrai. Enregistrement de cours permet aux instructeurs d'être plus engagés dans leur présentations de cours et de mieux comprendre les besoins d'apprentissage de leurs étudiants. Vu que ces derniers ne sont pas occupés à prendre des notes, ils sont libres d'interagir avec leur enseignant et peuvent mieux leur indiquer où des explications en profondeur ou des clarifications sont nécessaires afin d'améliorer leur apprentissage. Le rôle de l'enseignant est encore critique.

De plus, les cours effectués à travers ce medium ne sont pas ouverts à tous ; ils sont limités aux seuls étudiants de cette classe et leur accès est protégé par mot de passe. Ainsi, la propriété intellectuelle du cours reste à son enseignant.

Certains s'inquiètent que des étudiants ne viendraient plus en cours si l'accès à leur matériel de cours est disponible 24h sur 24, sept jours sur sept. Que se passe-t-il si certains étudiants ratent la classe ou ne viennent pas du tout en cours ? Au niveau universitaire, devrions-nous réellement nous inquiéter à propos de la présence des étudiants ? Quelles sont nos garanties que les étudiants apprennent réellement lorsqu'ils viennent en cours ? De bons professeurs attireront toujours des étudiants à leurs cours, même si celui-ci est enregistré. Et avec l'accès au matériel de cours, les étudiants ont l'option de choisir le cours en classe ou l'Enregistrement de cours, ou les deux.

Étant donné que la taille de nos salles de classe s'agrandit et qu'il est irréaliste de penser que nous pouvons avoir des interactions avec des classes aux tailles plus importantes et, plus encore, que les mathématiques sont complexes, l'Enregistrement de cours offre une solution résolvant ce dilemne. Si les étudiants choisissent de ne pas venir en classe car ils sont à l'aise avec le simple Enregistrement de cours, cela réduit la taille des classes et permet de meilleures interactions entre étudiants et professeurs, pour ceux d'entre eux qui se déplacent à la présentation du cours en classe.

Étant donné les nombreux avantages de l'Enregistrement de cours, étendons l'utilisation des technologies dans nos salles de classes sans être trop inquiets du changement apportés aux méthodes traditionnelles d'enseignement et d'apprentissage. Les temps changent (ou ont même déjà changé) ! Afin de garder l'enseignement des maths vivant et attrayant pour nos étudiants, nous devons changer avec lui.

*Book Reviews* brings interesting mathematical sciences and education publications drawn from across the entire spectrum of mathematics to the attention of the CMS readership. Comments, suggestions, and submissions are welcome.

**Karl Dilcher**, Dalhousie University ([notes-reviews@cms.math.ca](mailto:notes-reviews@cms.math.ca))

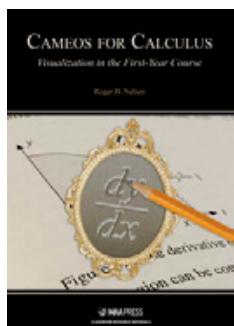
**Editor's Note:** In this issue we continue to feature books published by the MAA during its centennial year 2015. The four volumes below cover the related areas of calculus enrichment and beginning analysis. While these are just brief reviews, several full reviews of other interesting recent MAA volumes are currently in preparation.

## Cameos for Calculus: Visualization in the First-Year Course

by Roger B. Nelsen

MAA, 2015, 171 pp.

**ISBN: 978-1-61444-120-5**



Visualization is one of the most important tools in teaching undergraduate mathematics courses. We all use diagrams and graphs in our calculus classes, from quick improvised doodles to elaborate figures that support arguments in a proof. They are most effective when the connection between an identity or inequality and the corresponding diagram is clearly visible.

In the preface of this book, the author begins with the two different meanings of the word *cameo* as “a brief appearance of a known figure” (in film and theatre) or a “precious or semiprecious stone” (for gemologists). The fifty cameos in this book aim at combining these two definitions. Many of these visualizations are quite standard and can be found in most calculus textbooks. Others, however, are more unusual, are particularly clever and/or especially enlightening. Many cameos are reminiscent of the well-known “Proofs without words” books or columns, and indeed, the *College Mathematics Journal*, where they typically first appeared, is a standard source for much of this book. My personal favourite is Cameo 40 (“Approximating  $\pi$  with Maclaurin series”), where visual proofs of two arctan identities for  $\pi/4$  are presented.

Inequalities are particularly well represented in this book, which is one of its strengths. There are also two cameos each on hyperbolic functions and conic sections, two other topics that are all too often neglected in calculus courses. Most cameos come with exercises (with solutions in the back of the book), and all have a list of sources. Portraits of famous mathematicians can also be found throughout the book.

Les comptes-rendus de livres présentent aux lecteurs de la SMC des ouvrages intéressants sur les mathématiques et l'enseignement des mathématiques dans un large éventail de domaines et sous-domaines. Vos commentaires, suggestions et propositions sont le bienvenue.

**Karl Dilcher**, Dalhousie University ([notes-critiques@smc.math.ca](mailto:notes-critiques@smc.math.ca))

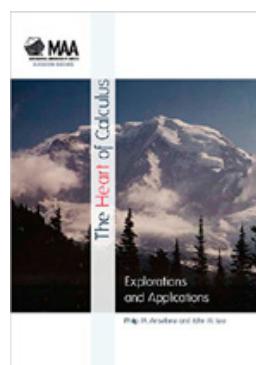
The five parts of this book (with the numbers of cameos) are *Limits and Differentiation* (15), *Integration* (17), *Infinite Series* (8), *Additional Topics* (5), and *Appendix: Some Precalculus Topics* (5). Even the most experienced Calculus instructor will likely find something new and useful in this slim volume.

## The Heart of Calculus: Explorations and Applications

By Philip M. Anselone and John W. Lee

MAA, 2015, 245 pp.

**ISBN: 978-0-88385-787-8**



According to the preface, “This book is intended primarily as enrichment material for courses in first and second year calculus. It also has material suitable for use in differential equations and introductory real analysis. We endeavor to offer an engaging combination of topics at a challenging, yet accessible level. The book targets talented and well-motivated students and can be used in a variety of settings, such as honors courses, undergraduate seminars, independent study, capstone courses taking a fresh look at calculus, and summer enrichment programs.”

Later the authors write, “Virtually all the chapters are natural complements to a first course on real analysis. Students can see for themselves how the results they are learning in real analysis arose out of the need and desire to set calculus on a firm foundation.”

The book begins with three chapters on the fundamentals of differential calculus, which form the basis for the remaining 13 chapters. However, some prior exposure to calculus is assumed. The majority of those later chapters can be described as more applied, and indeed, the authors state that “Mathematical modeling is an integral part of many chapters.” One notable exception is Chapter 8 (“ $\pi$  and  $e$  are Irrational”). Another interesting and (for a calculus book) unusual topic is “The Buffon Needle Problem”

(Chapter 10). The next six chapters are the most applied, namely “Optimal Location”, “Energy”, “Springs and Pendulums”, “Kepler’s Law of Planetary Motion”, “Newton’s Law of Universal Gravitation”, and “From Newton to Kepler and Beyond”.

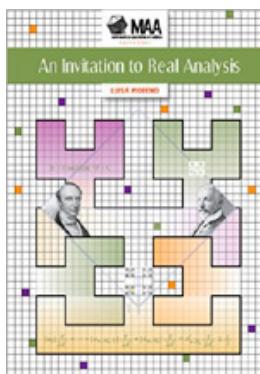
Each chapter begins with a brief (less than a page) introduction and ends with sections on “Problems and Remarks” and “Further Reading and Projects”, with a list of references that include history and biography related to the topic of the chapter. The Preface states that this book had its origin in an undergraduate honours seminar at Oregon State University. It does indeed appear to be an excellent basis for such a seminar.

## An Invitation to Real Analysis

by Luis F. Moreno

MAA, 2015, 680 pp.

**ISBN:** 978-1-93951-205-5



The title of this book suggests a friendly tone and a gentle introduction to real analysis. This does indeed seem to be the case, as the book’s size and reader-friendly layout suggest. In his notes “To the Instructor”, the author writes, “With this book I hope to ease a student’s transition from what may be called a ‘consumer of mathematics’ up through calculus II, into one beginning to participate in its creative process.”

The 55 chapters are quite short and might more properly be called sections, and the author suggests that in a 14-week semester most of the book could be covered. This seems rather ambitious, and it appears to me that it would be more suitable for a two-semester course (in the Canadian system of 12 or 13 weeks each) in second year.

Some nice features are a preliminary section on paradoxes, followed by five chapters on foundations, from logic to set theory. After this, all the standard topics of beginning analysis are covered. While quite reasonably the material is largely restricted to analysis on the real line, close to the end there are two chapters on metric spaces, followed by “Some Topology of the Real Number Line” and “The Cantor Ternary Set” as the final two chapters. The 30-page appendix contains, among others, a section on Farey sequences and one on continued fractions, topics that are more often found in beginning number theory courses, but are not out of place here.

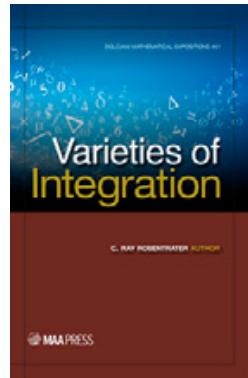
With almost 700 pages, this book is almost as large and heavy as the other three books in this column combined. Still, it is quite reasonably priced, and the value-added features appear to warrant the size. For instance, the approximately 600 exercises give rise to 93 pages of solutions to odd-numbered exercises. The annotated bibliography will be appreciated by both the instructor and by interested students.

## Varieties of Integration

by C. Ray Rosentrater

MAA, 2015, 342 pp.

**ISBN:** 978-0-88385-359-7



The content and the purpose of this book are best described by the text on the back cover: “Early in their studies, young mathematicians are introduced to three different definitions of the integral. Typically, the associated studies take place in isolation from each other and often are unconnected to the historical questions that gave rise to the definitions. *Varieties of Integration* provides a historically motivated, integrated survey of the most common integral definitions.”

Making clear pedagogy a priority the integrals are introduced using a common set of test functions and then compared in terms of (1) their common proof and computational strategies, (2) the breadth of their applications, and (3) their flexibility in dealing with limits.”

In his preface, the author considers this book a comparative study of four approaches to integration over an interval  $[a,b]$ : Riemann, Darboux, Lebesgue, and gauge. He continues by stating that the book can serve as a text for a second course in real analysis. “Indeed, this manuscript is written with such users particularly in mind. The prerequisite first course should include the standard topics of supremum, infimum, compactness, the mean value theorem, and sequences of functions. The reader should also be familiar with using the formal  $\epsilon - \delta$  definitions of limit and continuity in proofs.”

After a historical introduction (Ch. 1), including the names Newton and Leibniz; Cauchy, Riemann and Darboux; Lebesgue; and Henstock and Kurzweil, Chapters 2 and 3 are devoted to the Riemann and Darboux integrals, respectively. This is followed by two chapters entitled “A Functional Zoo” and “Another Approach: Measure Theory”. Chapters 6 and 7 are then devoted to the Lebesgue integral and the gauge integral. The final three chapters are “Stieltjes-type Integrals and Extensions”, “A Look Back”, and “Afterword:  $L_2$  Spaces and Fourier Series”. An appendix consists of a 10-page “Compendium of Definitions and Results”.

The book contains numerous examples and counterexamples, which will no doubt help students understand the definitions and concepts in question. Each chapter ends with several pages of exercises, and with a small list of references. This is a handsomely produced book (like most MAA publications), and it appears to be of just the right length and at the right level for the intended audience.

*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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*In this edition of the Education Notes we present two views on gatherings of mathematicians. The first view, provided by Edmund Kong, is on the experience of a high school student attending an international mathematics camp. The second view, provided by Miroslav Lovric, describes the Canadian Math Education Study Group and its forty years of successful communication between mathematics educators from all levels. These two articles, developed independently, stress the importance of creating environments that foster and support effective creative thought.*

## Reflection on *Tournament of Towns* Summer Conference 2015

**Edmund Kong**, Grade 9 (2014-15), Toronto,  
(Marc Garneau Collegiate Institute TOPS Program)

Last year, I was fortunate enough to be invited by the University of Toronto and the *Tournament of Towns* Committee to the *Tournament of Towns* 2015 Summer Conference, situated in the idyllic Republic of Adygea. The quiet atmosphere that only this locality could provide was the perfect environment for young mathematicians from around the world to tackle a variety of challenging mathematical problems. These ranged from modular arithmetic and radicals to algorithms, all of which captured my interest and attention.

Capitalizing on the importance of teamwork, Gemma Zhang (the other Toronto participant) and I invited two other participants, Rui Ming Xiong from Calgary and Chan Kai Chin from Malaysia, to pursue the topic *Solving Equations Using One Radical*. *Tournament of Towns* organizers were generous in providing us with total flexibility within our schedule so we could choose to work when our minds were fit for such challenges. We worked on math problems all day long; the calm environment was perfect for the task. The professors and jury members at the camp were particularly considerate and would give contestants their undivided attention.

Most questions from the Summer Conference for the *Tournament of Towns* promoted the methodical usage of lemmas to advance through the problems. Initially unaware of this format, my team struggled with some of the more challenging problem sets. Our sporadic and rather non-sequential approach towards questions



meant that we would often overlook the importance of proving some crucial lemmas first. Eventually my team began to understand the many ways in which these math problems were interconnected with one another.

Below is an excerpt of the original problem 6.3 parts (a), (b) and (c) in the section entitled “*Representability With Use of Only One Radical*,” which leads to the proof of the Conjugation Theorem. The investigation project is devoted to several classical methods and results in pure mathematics. Recent developments in computer science related to symbolic computations boosted interest in this area of research.

**6.3**  $Q$  is a set of rational numbers. We will consider polynomials with coefficients in  $Q$ .

Let  $q$  be a prime number, and let  $r \in \mathbb{R} \setminus \mathbb{Q}$  be a number such that  $r^q \in \mathbb{Q}$ .

(a) **Irreducibility Lemma.** The polynomial  $xq - rq$  is irreducible over  $Q$ .

(b) **Linear Independence Lemma.** If  $r$  is a root of a polynomial  $A$  whose degree is less than  $q$ , then  $A = 0$ .

(c) **Conjugation Theorem.** If  $r$  is a root of a polynomial, then all the numbers of the form  $r\varepsilon_q^k$ ,  $k = 1, 2, 3, \dots, (q-1)$  are also roots of this polynomial.

When we were not doing mathematics, officials of the *Tournament of Towns* provided contestants with excursions to nearby natural attractions. Every night, after a day of intellectual work, a traditional Russian festivity called a *Samovar* would be hosted where contestants could socialize and relax while enjoying a special black tea brewed from a traditional kettle for which the event is named. During one of these festive experiences, some of



the Russians challenged me to drink a highly concentrated black tea called "chifir". We ended up having a tea-drinking competition which was a great way to loosen up at the end of a tiring day.

This conference surpassed many others in recognizing the importance of having a clear and undisturbed mind when tackling challenging mathematical problems. This factor is often overlooked, even by the prestigious *International Mathematical Olympiads (IMO)*. A participant of the conference who was also an active contestant at IMO noted that IMO fostered a tense social environment and an unpleasant atmosphere due to rivalries that might perturb the contestants' states of mind.

Finally, I would like to express my sincere gratitude to Professor Kumar Murty, the Chair of the Department of Mathematics at University of Toronto, for building and endowing the *Tournament of Towns* program and providing financial support. Likewise, I want to extend my gratitude to the Moscow organizers and the Jury members for their expertise in identifying research topics accessible to high school students.

This was the best math conference I have attended to date. I hope this conference will continue in the future and that I can participate again. I appreciate the funding that has made this experience possible.

Thank You.

## CMESG/GCEDM — Canadian Mathematics Education Study Group / Groupe Canadien d'Étude en Didactique des Mathématiques

**Miroslav Lovric**, McMaster University

### Origins of CMESG/GCEDM

The Science Council of Canada sponsored a mathematics education conference at Queen's University, Kingston, Ontario, in September 1977. Thirty mathematicians and mathematics educators from across Canada accepted an invitation to join the three organizers (A. J. Coleman and W. C. Higginson of Queen's University, and D. H. Wheeler of Concordia University) in discussing the theme *Educating teachers of mathematics: the universities' responsibility*. Although the participants were university mathematics educators and mathematicians, the organizers did not intend to imply that only universities are or should be concerned with the education of future teachers. Universities have traditionally played a principal role, and will certainly continue to be involved in teacher education for the foreseeable future, even though the forms of their involvement change.

This first encounter generated a demand from many of the participants for further opportunities to meet and talk. The Science Council supported a second invitational meeting in June 1978 (again, at Queen's) at which the decision was taken to establish a continuing group, to be called the *Canadian Mathematics Education Study Group/Groupe Canadien d'Étude en Didactique des Mathématiques (CMESG/GCEDM)*, and to organize yearly conferences at locations across Canada. Initially envisioned as a meeting space for primarily university mathematicians and university mathematics educators, CMESG/GCEDM has grown into a truly diverse group, including elementary and high school teachers, college and university mathematics instructors, and graduate students and researchers in faculties of education and mathematics departments. Teacher education and mathematics education research, in the broadest sense, have remained among the primary foci of its activities to this day.

CMESG/GCEDM will mark its 40<sup>th</sup> anniversary at the meeting at Queen's University, 3-7 June 2016.

### CMESG Meetings

In many ways, CMESG/GCEDM meetings differ from usual academic meetings and conferences. They are kept small (initial attendance of 30-70 grew to an average of about 100, rarely exceeding 120 participants), in order to promote relaxed social environments which facilitate productive communication, discussion and debate. At a large conference, participants usually congregate toward their own research/interest group members, and stay there. At CMESG/GCEDM, it is not possible to hide within one's narrow

interests; for instance, the gap between research mathematicians, teacher educators and education researchers (still wide “out there”) disappears at CMESG/GCEDM, as participants present and discuss their views and ideas, for instance, in working groups. Moreover, small group size allows organizers to fine-tune themes and corresponding research ideas that will be primary activities at the meeting.

The defining (and distinguishing) features of CMESG meetings are its *working groups*. Each working group meets for 3 hours each morning of the three central days (as CMESG meetings begin around dinner time on Friday and conclude by lunch on Tuesday). Participants select groups based on their interests, working group abstracts published in the conference program released several months before the meeting, and a short “commercial” by working group leaders at the meeting’s opening ceremony. Switching groups is strongly discouraged - participants are expected to remain in the group they chose initially until the end.

Why working groups? The rationale is more than an acknowledgement that “two heads are better than one,” or that multiple perspectives on important issues are potentially more illuminating than unitary ones. It goes further and says that it is possible for a group of people to *work collaboratively* at a conference on a common theme and generate something fresh out of the knowledge and experience that each participant brings to it. This is not easy to achieve, in part because people are not used to working this way and have not yet learned the techniques. Newcomers sometimes feel that the first 3-hour session allotted to a working group is wasted because the group has come together without a common view on the topic, so everyone has to sit through the expression of a lot of different opinions before the group can actually start working.

The task of the group leaders (there are usually two or three) is to capitalize on the diversity of expectations and experiences within the group while fostering the pursuit of those emergent sub-themes which appear to be going somewhere. It is not surprising that this activity does not always lead to the sort of outcomes that can be immediately written down and polished into a conventional scholarly paper. A well-run working group handles complexity very effectively, but effective ways of recording its achievements are difficult to develop. However, in the months following the meeting, the group leaders, with the help of participants, produce a report, which is published in the proceedings.

The emphasis on working groups affects other aspects of the CMESG/GCEDM meetings. People are not divided disjointly into a set of those who present and a set of those who sit and listen. There are presentations of a conventional kind, but in the context of the meeting they also become subjects for a broad discussion.

For instance, there are usually two *plenary addresses*, one given by a mathematician and the other by a mathematics education researcher. An innovation which illustrates this “CMESG/GCEDM approach” is the discussion hour scheduled on the day following a plenary address, at which the members discuss the talk with the

speaker. Prior to this discussion hour, participants meet in small groups for half an hour to talk about the plenary, and to formulate questions. (As far as we know, no other conference or meeting offers this kind of activity.) Further there is an expectation that plenary speakers will be full participants in the entire meeting including participation in a working group.

CMESG/GCEDM program offers at least one slot in the timetable for *ad hoc sessions*. Any person may volunteer to make a presentation or to lead a discussion, and these items are added to the program on the spot, during the conference. Again, these sessions are not lectures—the key feature is discussion.

Furthermore, there are *invited topic sessions* (usually between two and four at each meeting) given by researchers in mathematics education. As well, new PhDs in mathematics education at all levels are given an opportunity to present their theses.

The intention of these various opportunities is to encourage all participants to take an active part in the meetings. The policy would be ineffective if it did not deliver, and if it were not situated in a relaxed and accepting atmosphere. As in school, people would soon stop making contributions if these kept getting shot down in flames. CMESG/GCEDM meetings are free of the point-making and competitiveness that are features of many academic gatherings. People *listen* to other people, with respect if not necessarily in agreement.

## Impact

With forty annual meetings to its credit, and a core of active members, CMESG/ GCEDM is a well-established organization. In an important sense CMESG/GCEDM is its annual meetings since these are where what is characteristic of CMESG/GCEDM actually takes place—its study-in-cooperative-action.

While many provinces have provincial mathematics teacher associations, CMESG/GCEDM along with the CMS Education Committee (whose natural interest inclines more toward the teaching of mathematics at the tertiary level) are the only two organizations that operate at a *national* level. However, there is no national voice speaking about mathematics education to the government and to the public. CMESG/GCEDM lacks a powerful voice, but it has influenced, perhaps changed, a number of individuals.

CMESG/GCEDM takes as its essential position that the teaching of mathematics and all the human activities that are connected to it can, and should, be *studied*, whether the study has the form of an individual’s reflections, the reasoned argument of professional colleagues, or the more formal questioning of empirical or scholarly research. With this emphasis, CMESG/GCEDM has signalled to Canadian mathematics educators the importance of scholarship and research. Its meetings provide a forum where research plans can be discussed and create an encouraging atmosphere where novice researchers can find out how to begin.

In brief, through its activities, CMESG/GCEDM has given mathematics educators a taste for research. It has shown them that

their puzzlement about some aspects of mathematics is shared by many mathematicians. It has shown mathematicians that learning can be, and has to be studied and that teaching is in no way trivial. A sufficient number of such small victories could launch a revolution.

## CMESG/GCEDM 2016 Meeting

Preparations for the next meeting, from 3-7 June 2016 at Queen's University are well under way. To illustrate the scope of the themes, we list the titles of working groups and give names of their leaders. Abstracts for the working groups, plenary addresses, and other activities can be found online in both French and English at the CMESG/GCEDM page <http://www.cmesg.org/>. Proceedings of past meetings are also accessible at the site.

Working Group A (Chantal Buteau, George Gadanidis, Miroslav Lovric and Eric Muller): Computational Thinking and Mathematics Curriculum

Working Group B (Frédéric Gourdeau and Kathy Nolan): Mathematics in Teacher Education: What, How ... and Why?

Working Group C (Elena Polotskaia, David Reid, and Richard Hoshino): Problem-Solving: Definition, Role, and Pedagogy

Working Group D (David Guillemette and Cynthia Nicol): Mathematics Education and Social Justice: Learning to Meet the Others in the Classroom

Working Group E (Patricia Marchand and Nathalie Sinclair): Role of Spatial Reasoning in Mathematics

Working Group F (Annie Savard and Elaine Simmt): The Public Discourse About Mathematics and Mathematics Education

### Note

Large parts of this article have been taken and adapted from the paper, *The Origins and Activities of CMESG*, written by David Wheeler and published online at <http://www.cmesg.org/about-cmesg/>. The paper was originally written for the monograph *Current Research on the Teaching and Learning of Mathematics in Canada — Les Recherches en Cours sur l'Apprentissage et l'Enseignement des Mathématiques au Canada* edited by Carolyn Kieran and A. J. (Sandy) Dawson and published for ICME-7 in 1992.

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## AARMS Summer School 2016 at Dalhousie University

The fifteenth annual Summer School sponsored by the Atlantic Association for Research in the Mathematical Sciences (AARMS) will take place at Dalhousie University in Halifax, Nova Scotia, Canada, from July 11 until August 5, 2016. The school, which offers courses in the mathematical sciences and their applications, is intended for exceptional undergraduate students and graduate students from all parts of the world. Each participant will be expected to register for two courses, each with five ninety-minute lectures per week. These are graduate courses, approved by Dalhousie, and we will facilitate transfer credits to the extent possible. If you are accepted for this Summer School, you won't need to pay tuition at Dalhousie and the cost for accommodation in special dormitory houses (which will only be shared with other summer school participants) is covered by AARMS. This will be an excellent opportunity to study together with other students in your field of interest and to make contact with experts in your area. Over the weekends there will be social activities and excursions to explore Nova Scotia.

### For 2016 the following courses are planned:

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#### Categories, Quantum Computation and Topology

Instructor: Dr. Jamie Vicary, University of Oxford

#### Stable Polynomials, with Applications

Instructor: Dr. David Wagner, University of Waterloo

#### An Introduction to Special Functions and WZ Theory

Instructor: Dr. Armin Straub, University of South Alabama

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*Research Notes brings mathematical research ideas forth to the CMS readership in a generally accessible manner that promotes discussion of relevant topics including research (both pure and applied), activities, and noteworthy news items. Comments, suggestions, and submissions are welcome.*

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## Left-Orderability Of 3-Manifold Fundamental Groups

**Adam Clay**, University of Manitoba

A group  $G$  is said to be *left-orderable* if there exists a strict total ordering  $<$  of its elements such that  $g < h$  implies  $fg < fh$  for all  $f, g, h \in G$ . At first blush, left-orderability may seem algebraic in nature. However it is inherently a topological and dynamical property, with each ordering of  $G$  encoding dynamical information about a particular  $G$ -action on the real line.

**Theorem 0.1.** *If  $G$  is a countable group, then  $G$  is left-orderable if and only if  $G$  acts faithfully on the real line by order-preserving homeomorphisms.*

One approach to the difficult direction of the proof is to embed your countable left-ordered group  $G$  in  $G \times \mathbb{Q}$ , ordered lexicographically. Then  $G \times \mathbb{Q}$  admits a strict total ordering which is dense and has no largest or smallest element, so it is order-isomorphic to the rationals by a theorem of Cantor. The natural left-action of  $G \times \mathbb{Q}$  on itself then becomes an action of  $G \times \mathbb{Q}$  on the rationals, which preserves order since  $G \times \mathbb{Q}$  is left-ordered. This action continuously extends in a unique way to  $\mathbb{R}$ . One need only check that the action of  $G$  built in this way has the required properties.

Though the theorem requires us to restrict our attention to countable groups, it still applies to all finitely generated groups. Then for arbitrary groups, a quick compactness argument can be used to show that they're left-orderable if and only if all of their finitely generated subgroups are left-orderable. So even in the case of uncountable groups, this theorem still gives us an accurate local picture.

For a low-dimensional topologist, 3-manifolds then naturally enter the picture via their fundamental groups, as many of them turn out to have actions on  $\mathbb{R}$  by order-preserving homeomorphisms for topological reasons. For ease of presentation, all 3-manifolds in this discussion are assumed to be compact, connected, and orientable unless otherwise stated.

One of the earliest theorems concerning left-orderability of 3-manifold fundamental groups used codimension one foliations to construct such an action. A codimension one foliation of a 3-manifold is a way of writing the 3-manifold as a disjoint union of surfaces, called leaves. Such a foliation is called *co-orientable* if the leaves can all be coherently oriented, and *taut* if there's a circle in the 3-manifold which transversely intersects every leaf.

Les articles de recherche présentent des sujets mathématiques aux lecteurs de la SMC dans un format généralement accessible qui favorise les discussions sur divers sujets pertinents, dont la recherche (pure et appliquée), les activités et des nouvelles dignes de mention. Vos commentaires, suggestions et propositions sont le bienvenue.

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**Theorem 0.2.** [3] *Let  $M$  be an irreducible, atoroidal rational homology 3-sphere that admits a co-orientable, taut foliation. Then the commutator subgroup  $[\pi_1(M), \pi_1(M)]$  is left-orderable. In particular, if  $H_1(M) = 0$  then  $\pi_1(M)$  itself is left-orderable.*

Their proof uses the fact that a co-orientable taut foliation on a 3-manifold  $M$  yields an action of  $\pi_1(M)$  on  $S^1$  via Thurston's universal circle construction, and it lifts to an action on  $\mathbb{R}$  under appropriate conditions. The result follows from applying the equivalence above. The authors also gave examples of 3-manifolds whose fundamental groups are not left-orderable. For example, the fundamental group of the Weeks manifold—the hyperbolic 3-manifold of smallest volume—is not left-orderable.

Shortly thereafter, a fundamental connection with quotients of  $\pi_1(M)$  followed:

**Theorem 0.3.** [4] *Let  $M$  be an irreducible 3-manifold. Then  $\pi_1(M)$  is left-orderable if and only if there is a surjection  $\pi_1(M) \rightarrow L$  onto a nontrivial left-orderable group  $L$ .*

This implies, for example, that a 3-manifold with infinite first homology has left-orderable fundamental group since there's a map  $\pi_1(M) \rightarrow H_1(M) \rightarrow \mathbb{Z}$ . The proof of this theorem is distinctly topological and uses Scott's so-called "compact core theorem". It's also easy to see that among dimensions larger than two, this theorem is unique to dimension three: Every finitely presented group arises as the fundamental group of a smooth 4-manifold, so any finitely presented group admitting torsion and possessing a map onto  $\mathbb{Z}$  provides proof that the theorem cannot hold in dimension four (or higher).

Looking for an explanation as to why some fundamental groups in dimension three are left-orderable and others are not, many observed a correlation between left-orderability, co-orientable taut foliations, and Heegaard-Floer homology—a correlation now formalized as a conjecture. Heegaard-Floer homology associates an abelian group  $\widehat{HF}(M)$  to a 3-manifold  $M$ , and an *L-space* is a rational homology 3-sphere whose Heegaard-Floer homology is as simple as possible, in the sense that  $\text{rank}(\widehat{HF}(M)) = |H_1(M)|$  (in general, we have  $\text{rank}(\widehat{HF}(M)) \geq |H_1(M)|$ ).

**Conjecture 0.4.** *Let  $M$  be an irreducible rational homology 3-sphere. Then the following are equivalent:*

- (1) *The fundamental group of  $M$  is left-orderable.*
- (2) *The manifold  $M$  admits a co-orientable taut foliation.*
- (3) *The manifold  $M$  is not an L-space.*

Statements (1) and (3) in the theorem above were conjectured to be equivalent in [4], where the authors also showed that (1) and (3) are equivalent for all geometric non-hyperbolic 3-manifolds, the equivalence of (1) and (2) for such manifolds being known from [5]. Statement (3) then appears as part of the conjecture in [9].

With the conjecture confirmed for geometric non-hyperbolic 3-manifolds, what remains is the case when  $M$  is hyperbolic, and when  $M$  can be built out of geometric pieces glued together along a family of embedded, incompressible tori. The latter has seen a considerable amount of attention in recent years, with particular focus on the case of graph manifolds. Recall that a 3-manifold  $W$  which is cut into Seifert fibred pieces  $M_1, \dots, M_n$  by tori  $T_1, \dots, T_m$ , called the JSJ tori, is called a graph manifold.

**Theorem 0.5.** [2, 3, 8, 7, 11, 10, 1] *The conjecture is true if we restrict to graph manifold rational homology 3-spheres.*

Despite being spread over several works by different authors, the underlying theme of the proof runs clearly through every paper. For each torus  $T_j$  in the graph manifold  $W$ , call an element of  $\mathbb{P}H_1(T_j; \mathbb{R})$  a *slope* on  $T_j$ . Each of the three structures in the conjecture—a left ordering of  $\pi_1(M_i)$ , a co-orientable taut foliation of the piece  $M_i$ , and the Heegaard-Floer homology of  $M_i$ —offers a way of determining a slope on each boundary torus  $T_j$  of the Seifert fibred piece  $M_i$ . For Seifert fibred manifolds, each of these three methods will detect the same set of slopes. Then if the gluing maps which reassemble  $W$  from its Seifert fibred pieces identify a pair of detected slopes on every JSJ torus  $T_j$ ,  $1 \leq j \leq m$ , the structures on the pieces  $M_1, \dots, M_n$  ‘fit together’. That is, foliations of the pieces  $M_i$  become a foliation of  $W$  itself, left-orderings of the groups  $\pi_1(M_i)$  become a left-ordering of  $\pi_1(W)$ , and  $W$  is not an L-space (each of the pieces  $M_i$  is not an L-space by definition).

At present this strategy is only well-adapted to Seifert fibred pieces. However, with adjustments to the definitions and techniques, it may allow an analysis of 3-manifolds built using hyperbolic pieces as well.

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## Call for Nominations: Student Committee Roles

The CMS Student Committee is looking for proactive mathematics students interested in joining the Committee in the roles of chair, regional representatives for Quebec and Ontario, and English-to-French translator. Francophone applicants are preferred for the positions of translator and regional representative for Quebec. If you are interested, or know someone who may be, please visit our website <https://studc.math.ca> for more information and an application form. If you have any questions, please contact us at [chair-studc@cms.math.ca](mailto:chair-studc@cms.math.ca).

## Appel à candidature: postes pour le comité étudiant de la SMC

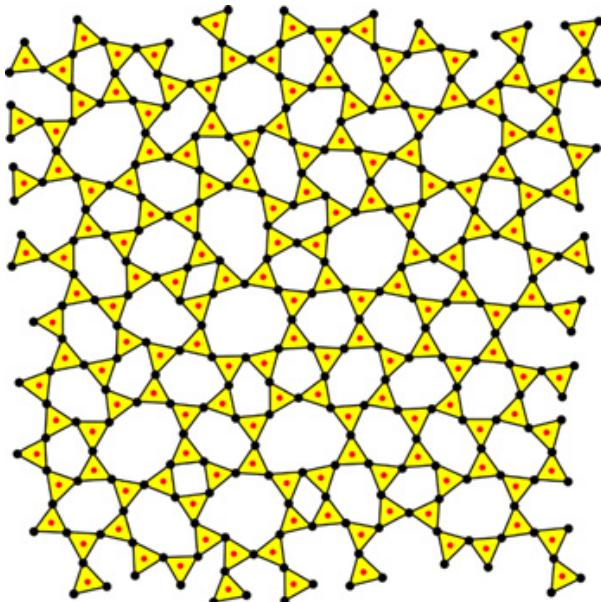
Le comité étudiant de la SMC est à la recherche d'étudiants en mathématiques dynamiques qui seraient intéressés à joindre le comité étudiant pour combler les postes du président, représentants régionaux pour le Québec et pour l'Ontario, et du traducteur anglais-français. Les applicants francophones seront préférés pour les postes du traducteur et du représentatif régional pour le Québec. Si vous êtes intéressé ou connaissez quelqu'un qui pourrait l'être, veuillez consulter notre site web <https://studc.math.ca> pour plus d'informations et pour télécharger le formulaire d'application. Pour toute question, veuillez nous écrire à [pres-studc@smc.math.ca](mailto:pres-studc@smc.math.ca).

## Anchored Boundary Conditions For Locally Isostatic Networks

**Elissa Ross**, MESH Consultants Inc., Fields Institute for Research in the Mathematical Sciences

**B**oundary conditions are an essential consideration throughout many areas of scientific computer simulation. When modelling materials at the atomic level, we may wish to draw conclusions about properties of the bulk from an observation of a sample. Typically the boundary alters the properties of the sample by the ratio of the number of surface atoms to the number in the bulk. In the thermodynamic limit, as the size of the system increases, this ratio goes to zero. Similar statements are true about the mechanical and vibrational properties of a system, *except* for those systems which lie on the border of mechanical instability (*isostatic* systems). In such cases, the boundary conditions are important no matter how many atoms the system contains.

An example of such a system is vitreous silica ( $SiO_2$ ), which can be imagined as two layers of tetrahedra which are mirror images of each other and meet at the apices of each pair of mirrored tetrahedra (Figure 1).



**Figure 1.** A piece of bilayer of vitreous silica imaged in SPM (Scanning Probe Microscope) [3]. We represent the  $Si$  atoms as red discs and the  $O$  atoms as black discs. Local covalent bonding yields the almost-equilateral triangles, which are freely jointed. The surface triangles have either one or two vertices *unpinned*, and all other vertices are called *pinned*.

The corner-sharing triangle network shown in Figure 1 has the property that the number of degrees of freedom of the equilateral triangles in the plane is exactly balanced by the shared pinning constraints at each non-boundary vertex. We call such a network *locally isostatic*, and we can think of this as being stable or rigid, but only barely so. This condition is destroyed at the boundary,

where the unpinned triangles are free to move, and could propagate flexibility toward the inside of the sample. Because the network is locally isostatic, intuitively, the degrees of freedom of systems like the one shown in Figure 1 correspond exactly to the unpinned triangles, and therefore finding a “good” way to pin these boundary triangles should generate the desired boundary conditions. A rigorous proof of this fact involves showing that there are no *additional* degrees of freedom resulting from sub-networks which contain more constraints than degrees of freedom [1].

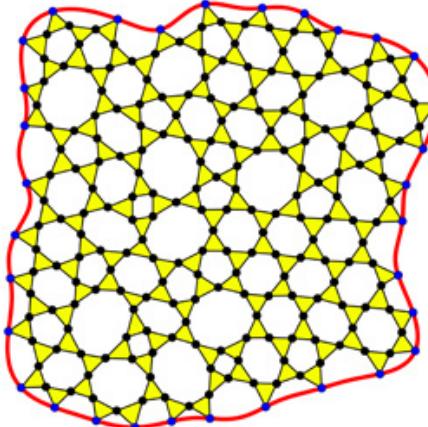
In [1] we define boundary conditions for graphs which capture the combinatorics of silica bilayers. We then describe two methods to completely immobilize a finite piece of such a network (Figures 2 and 3). The methods used in [1] come from *combinatorial rigidity*, which is concerned with the rigidity or flexibility of structures. One of the key ideas is that *generically* the mechanical properties of an embedded graph is determined by its combinatorics alone. A generic realization is, roughly speaking, one without any special geometry, and our results are for this case.

To define a combinatorial model to describe silica bilayers, consider the graph  $G = (V, E)$  defined from Figure 1 by replacing each triangle by a vertex, and connecting two vertices by an edge if the corresponding triangles are pinned together. Let a *triangle ring network* be a graph  $G = (V, E)$  such that

- (1)  $G$  has vertices of degree 2 and 3 only, and  $G$  is 2-connected,
- (2) there is a simple cycle  $C$  in  $G$  that contains all the degree 2 vertices, and there are at least 3 of these,
- (3) any edge cut set in  $G$  that disconnects a subgraph containing only degree 3 vertices has size at least 3.

We now describe two ways of *pinning*, that is, completely immobilizing the network. A *slider* constrains the motion of a point to remain on a fixed line that is rigidly attached to the plane. A network with generically placed sliders is *pinned-isostatic* if it is pinned, but removing any pin or slider destroys this stability [2].

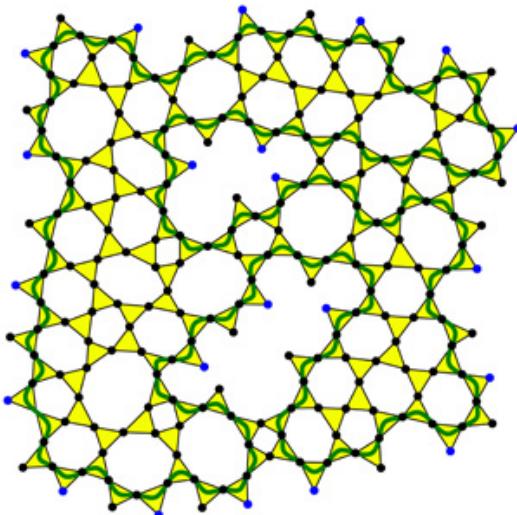
**Theorem 1.** *Adding one slider to each degree 2 boundary vertex of a triangle ring network  $G$  gives a pinned-isostatic network (Figure 2).*



**Figure 2.** Illustrating sliding boundary conditions, used for a piece of the sample shown in Figure 1.

We next consider completely pinning some of the boundary vertices, which we model combinatorially by placing two sliders at that vertex. Although it is natural to think of  $G$  as a planar graph with  $C$  as the outer boundary, in fact the combinatorial set-up is more general. Figure 3 illustrates a more complex sample with interior holes.

**Theorem 2.** *Let  $G$  be a triangle ring network with an even number of degree 2 vertices on the boundary cycle  $C$ . Then, pinning every other boundary vertex that is encountered while following  $C$  in cyclic order produces a pinned-isostatic network (Figure 3).*



**Figure 3.** Illustrating the anchored boundary conditions used on a sample involving internal holes. The alternating anchored sites on the boundary are shown as blue discs.

## Acknowledgements

This work was initiated at the AIM workshop on configuration spaces. The figures are reproduced from [1], and were prepared by M. Sadjadi.

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## The Value of “Dated” Histories of Mathematics

**Amy Ackerberg-Hastings**, University of Maryland University College

Efforts to write comprehensive histories of mathematics date back to at least the 16<sup>th</sup> century, although the best-known early work is the pioneering two-volume *Histoire des mathématiques* published in 1758 by Jean Étienne Montucla. While the discipline of history of mathematics thus has its own extensive history, older books and articles on the subject are rarely read today. After all, historians constantly search for previously unknown evidence and reevaluate existing interpretations of how and why events unfolded as they did. Their accounts inexorably become outdated.

So, instructors who decide to read about the history of mathematics or who are called upon to teach a history of mathematics class are likely to choose a relatively recent secondary source. Indeed, a wealth of excellent textbooks, monographs, and research articles have appeared in the past twenty-five years; some of this work has been described in previous installments of this column.

Yet those earlier histories on library shelves or in digitized book collections can still serve a purpose. For example, in addition to telling us about mathematical developments, they provide insight into how the history of mathematics was understood at the time and place of the author. In other words, these secondary sources evolve into primary sources. One such work is Florian Cajori's 1890 *Teaching and History of Mathematics in the United States*. Several copies are online, including [archive.org/details/teachingandhist00cajog0og](http://archive.org/details/teachingandhist00cajog0og).

Cajori (1859–1930) compiled information for *Teaching and History* between teaching positions at Tulane University (1885–1888) and Colorado College (1889–1918), drawing in part on a substantive library then held by the U.S. Bureau of Education, an office within the Department of the Interior. He wrote three main chapters, covering “colonial times” (1636–ca 1792); the “influx of English mathematics” (1776–1820); and the “influx of French mathematics” (ca 1807–1888). Each chapter was divided into accounts of postsecondary institutions active during that period. The 24 colleges discussed included Harvard, Yale, and West Point—three of the largest influences on American teaching in the 18<sup>th</sup> and 19<sup>th</sup> centuries—but also places such as Bowdoin, Georgetown,

*Les articles de la SCHPM présentent des travaux de recherche en histoire et en philosophie des mathématiques à la communauté mathématique élargie. Les auteurs sont membres de la Société canadienne d'histoire et de philosophie des mathématiques (SCHPM). Vos commentaires et suggestions sont le bienvenue; ils peuvent être adressées à l'une des co-rédacteurs.*

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and Kentucky. Cajori also wrote sections on a few other topics: elementary schools, self-taught mathematicians, government surveying, and journals.

A fourth chapter shared the unprocessed data collected during a survey on “mathematical teaching at the present time” from 168 colleges and universities, 45 normal schools, and 181 academies, institutes, and high schools. Cajori closed the book with a chronological annotated bibliography of fluxions and calculus textbooks printed in the United States and five “historical essays” on infinite series, parallel lines, the foundations of algebra, the differences between Napier’s and natural logarithms, and circle squarers.

Even today, *Teaching and History* is incredibly important to historians of American mathematics for the information it reports—in other words, as a secondary source. Cajori included facts and reminiscences that were otherwise difficult for researchers to track down before the recent explosion of digitized published books. Indeed, identifying and locating Cajori’s references is a good exercise that helps students discover the resources available from websites such as the Internet Archive and Google Books. The exercise can also be used to encourage students to think about how they use sources in their own writing and about their own citation practices.

Present-day historians of mathematics education also continue to respond to the argument suggested by the overall structure of *Teaching and History*, that American educators first consulted British mathematics textbooks and then laid those works aside to teach from French texts. An awareness of Cajori’s thesis is thus essential if students or instructors happen to be reading about the history of American mathematics education. His decisions about what the history of mathematics education is about also helped shape later conceptions of the subject. In particular, for Cajori textbooks were the curriculum and vice versa. Only in the past few decades have historians of mathematics education thought systematically about other aspects of teaching and learning. (*Teaching and History* does have a few brief references to teaching tools such as blackboards and mathematical instruments.) It can be useful in mathematics-education courses to ask students to think about relationships between teachers and students and about the materials that help people comprehend and work with concepts.

Furthermore, students can be guided into questions about the organization and style of *Teaching and History* without needing to know about the specific historical contexts of the events Cajori described or about historiography (the theory and practice of writing history). For instance, do they find engaging or tedious Cajori's habit of writing about one college in detail before moving on to the next? How does his writing voice compare to those in their textbooks or to a volume such as William Dunham's 1991 *Journey Through Genius*? Why, in their opinion, have authors like Cajori or Dunham endured while others were forgotten? What topics did he include, and which did he omit? How should a history of mathematics education be written? These questions, as well as the exercise about Cajori's bibliographic trails, are probably not typical inclusions in courses on history of mathematics or mathematics education. Spending some time on training in research and writing practices, though, can make an enormous difference in the quality of work produced by students.

These ways of thinking about *Teaching and History* also illustrate how the book has evolved into a primary source, how it has become an example of how scholars wrote about the history of mathematics 125 years ago. The more traditional way in which the book serves as a primary source is with the survey in chapter four. Historians have made attempts to analyze parts of the responses; David L. Roberts's 2012 *American Mathematicians as Educators, 1893–1923*, is one example. Still, ample room remains for students to try to make sense of the data. One final possible student project is to assign them to update the appendices. What have historians learned about these topics since 1890?

The suggestions in this column could be applied to other old books. Despite its long history of mathematical activity, Canada does not appear to have a late 19<sup>th</sup>- or early 20<sup>th</sup>-century equivalent to Cajori's volume. But for education in general, instructors can explore J. George Hodgins's 1908 *Documentary History of Education in Upper Canada*, [archive.org/details/docuhistoryupcanada00hodguoft](http://archive.org/details/docuhistoryupcanada00hodguoft), or *Education in Parts of the British Empire*, U.S. Department of Education *Bulletin* No. 49 (1919), [archive.org/details/educationinparts00unit](http://archive.org/details/educationinparts00unit). For the broader history of mathematics, see, for instance, Cajori's other books or those by David Eugene Smith or W. W. Rouse Ball, listed in their respective *Wikipedia* articles.

Students and faculty who want to dig into current scholarship on the history of Canadian mathematics and mathematics education can start with Thomas Archibald and Louis Charbonneau, "Mathematics in Canada before 1945: A Preliminary Survey," in *Mathematics and the Historian's Craft*, ed. Glen Van Brummelen and Michael Kinyon (Springer, 2005); Alexander Karp and Gert Schubring, eds., *Handbook on the History of Mathematics Education* (Springer, 2014); and George M. A. Stanic and Jeremy Kilpatrick, *A History of School Mathematics*, 2 vol. (NCTM, 2003).

*Amy Ackerberg-Hastings edits the Bulletin, CSHPM's semiannual newsletter. She specializes in researching the history of mathematics education in the United States and Scotland and in teaching historical research methods and writing.*

## New! CMS-Air Canada Program



The CMS is proud to announce that we are now part of the **CMS/Aeroplan Charitable Pooling** program for non-profit organizations. Charitable Pooling is a mechanism by which Air Canada passengers can donate some or all of their earned frequent flyer miles to a non-profit organization. The organization can then use those miles to pay airfares for travel that aligns with the organization's mission.

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<https://beyondmiles.aeroplan.com/eng/charity/941>

## Nouveau programme de la SMC avec Air Canada



La SMC est fière de vous annoncer que nous faisons désormais partie du programme de **fonds d'entraide SMC/Aéroplan** pour les organismes à but non-lucratif. Le fonds d'entraide permet aux passagers d'Air Canada de donner quelques ou tous leurs milles de voyageur assidu à un organisme à but non-lucratif. L'organisme peut ensuite utiliser ces milles afin de payer les billets d'avion qui correspondent à sa mission.

Dans le cas de la SMC, nous allons principalement utiliser les milles de voyageur assidu qui seront donnés à notre compte de fonds d'entraide afin de fournir les billets d'avion pour l'équipe de l'OIM ou pour faire voyager des étudiants diplômés ou en post-doctorat participants aux réunions de la SMC.

Étant donné que n'importe qui peut donner ses milles de voyageur assidu d'Air Canada, veuillez passer le mot à vos collègues, votre famille et vos amis. La SMC va publiciser cette opportunité de dons de milles de voyageur assidu au public.

Si vous souhaitez donner vos milles de voyageur assidu à la SMC, veuillez consulter le lien suivant :

<https://beyondmiles.aeroplan.com/fra/charity/941>



June 24 - 27, 2016, Edmonton, Alberta  
 University of Alberta  
[cms.math.ca/Events/summer16/](http://cms.math.ca/Events/summer16/)

## Prizes | Prix

**Coxeter-James Prize | Prix Coxeter-James**  
 recipient to be announced / lauréat à confirmer

**Excellence in Teaching Award | Prix d'excellence en enseignement**  
 recipient to be announced / lauréat à confirmer

**Krieger-Nelson Prize | Prix Krieger-Nelson**  
 recipient to be announced / lauréat à confirmer

## Public Lectures | Conférences publiques

Yuval Peres (Microsoft)

## Confirmed Regular Sessions | Sessions générales confirmées

**Algebraic Design Theory | Théorie de la conception algébrique**  
 Hadi Kharigani (Lethbridge)

**Algebraic Graph Theory: including Cayley graphs, group actions on graphs, graph eigenvalues, graphs and matrices | Théorie des graphes : y compris les graphes de Cayley, les actions de groupe sur les graphes, la valeur propre du graphe, les graphes et les matrices**  
 Joy Morris (Lethbridge)

**Analysis and Applications of Differential Equations using Symmetries, Conservation laws, and Integrability | Analyse et applications d'équations différentielles utilisant des symétries, les lois de la conservation et l'intégrabilité**  
 Stephen Anco (Brock), Anton Cheviakov (Saskatchewan)

**Analytic Number Theory and Diophantine Equations | Théorie analytique des nombres et équations diophantiennes**  
 Michael Bennett (UBC), Patrick Ingram (Colorado State)

**Computational Number Theory | Théorie algorithmique des nombres**  
 Kevin Hare(Waterloo), Patrick Ingram (Colorado State)

**Geometric Methods in Mechanics and Control with Applications | Méthodes géométriques en mécanique et contrôle avec applications**  
 Vakhtang Putkaradze (Alberta), Dmitry Zenkov (NCSU)

24-27 juin 2016, Edmonton (Alberta)  
 l'Université de l'Alberta  
[smc.math.ca/Reunions/ete16/](http://smc.math.ca/Reunions/ete16/)

## Plenary Speakers | Conférences plénierées

Andrea Bertozzi (UCLA)  
 Andrew Granville (Montreal)  
 Rachel Kuske (UBC)  
 Tatiana Shubin (San Jose State University)

## Scientific Director | Directeur scientifique

Anthony Quas (Victoria)  
 Marcelo Laca (Victoria)

## Industrial Mathematics | Mécanique industrielle

Huaxiong Huang (York), Michael Lamoureux (Calgary),  
 Odile Marcotte (UQAM)

**Partial Differential Equations | Équations aux dérivées partielles**  
 Mostafa Fazly (Alberta), Juncheng Wei (UBC)

**Representation Theory | Théorie des représentations**  
 Thomas Creutzig, Nicolas Guay (Alberta)

**Special Session on Combinatorial Games to celebrate Richard K. Guy's 100<sup>th</sup> Birthday | Session spéciale sur les jeux combinatoires pour célébrer le 100<sup>e</sup> anniversaire de Richard K. Guy**

Richard Nowakowski (Dalhousie)

**Theoretical and numerical methods in nonlinear analysis with real-world applications | Méthodes théoriques et numériques de l'analyse non linéaire avec applications réelles**  
 Fabrice Colin and Albert Nina Sandjo (Laurentian)

**AARMS-CMS Student Poster Session | Présentations par affiches pour étudiants AARMS/SMC**  
 Svenja Huntemann (Dalhousie)

## Contributed Papers | Communications libres

## CMS Member Profile / Profil membre de la SMC

### Svenja Huntemann

**HOME:** Dalhousie University (Halifax, NS)

**CMS MEMBER SINCE:** 2010

**RESEARCH:** Combinatorial game theory, especially connections to combinatorial commutative algebra

I am currently holding an NSERC CGS-D and a Killam Pre-Doctoral scholarship. I also received the AARMS Poster Award at the 2013 Summer Meeting.

Somehow doing the epsilon-delta definition of continuity in grade 10 has really stuck with me. It probably helped that my math teacher was quite good at drawing graphs.

**HOBBIES:** Horseback riding, reading, crochet

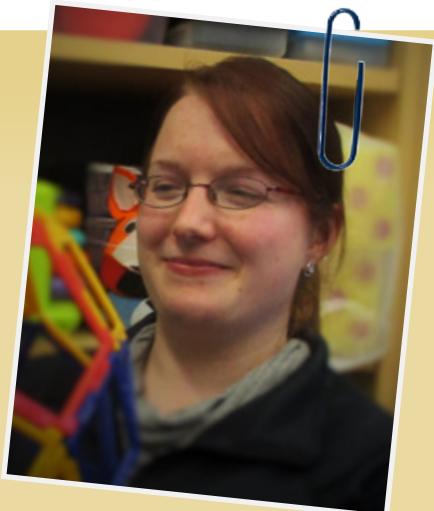
**LATEST BOOK READ:** "Mathematics, Magic and Mystery" by Martin Gardner. I am program director of the outreach

program NS Math Circles, and we are currently looking for new magic tricks to do with elementary school kids.

**LATEST PUBLICATION:** "Doppelgänger Placement Games" with Richard Nowakowski. And I am currently working on a paper demonstrating that each simplicial complex corresponds to a game, with my supervisors Sara Faridi and Richard Nowakowski.

**WHAT I WOULD CHANGE (ABOUT THE CMS):** Mostly having more students involved. It would also be nice to have a stronger connection with primary and secondary school educators.

**CMS ROLES:** Student Committee member since 2013, Education Committee Studc rep 2013-2015, and current Student Director on the CMS Board.



**WHY I BELONG TO THE CMS:** I think it is important to have a national voice, and to have student representation with that - after all, any decisions made now will influence future mathematicians the most. And I quite enjoy getting to know people from all across Canada.

## Winter Meeting – December 2-5, 2016 Sheraton on the Falls, Niagara Falls, Ontario

### Call For Sessions

The Canadian Mathematical Society (CMS) welcomes and invites proposals for sessions for the 2016 Winter Meeting in Niagara Falls. Proposals should include a brief description of the focus and purpose of the session, the expected number of speakers, as well as the organizer's name, complete address, telephone number, e-mail address, etc. All sessions will be advertised in the CMS Notes, on the web site and in the AMS Notices. Speakers will be requested to submit abstracts, which will be published on the web site and in the meeting program. Those wishing to organize a session should send a proposal to the Canadian Mathematical Society by **March 31, 2016**.

Please submit proposals to: [meetings@cms.math.ca](mailto:meetings@cms.math.ca)

## Réunion d'hiver – 2-5 décembre 2016 Sheraton on the Falls, Niagara Falls (Ontario)

### Appel de proposition de séances

Nous vous invitons – et tout particulièrement les universités locales – à proposer des sessions pour la Réunion d'hiver 2016, qui se tiendra à Niagara Falls. Ces dernières doivent inclure une brève description de l'orientation et des objectifs de la session, le nombre de conférenciers prévus ainsi que le nom, l'adresse complète, le numéro de téléphone et l'adresse courriel de l'organisateur. Toutes les sessions seront annoncées dans les Notes de la SMC et sur le site Web. Les conférenciers devront présenter un résumé, qui sera publié sur le site Web et dans le programme de la Réunion. Toute personne qui souhaiterait organiser une session est priée de faire parvenir une proposition à la Société mathématique du Canada au plus tard le **31 mars 2016**.

Pour les soumissions de résumé : [reunions@smc.math.ca](mailto:reunions@smc.math.ca)



## Call for Nominations – Adrien Pouliot Award

Nominations of individuals or teams of individuals who have made significant and sustained contributions to mathematics education in Canada are solicited. Such contributions are to be interpreted in the broadest possible sense and might include: community outreach programs, the development of a new program in either an academic or industrial setting, publicizing mathematics so as to make mathematics accessible to the general public, developing mathematics displays, establishing and supporting mathematics conferences and competitions for students, etc.

Nominations must be received by the CMS Office no later than **April 30, 2016**. For more information, visit: <https://cms.math.ca/Prizes/ed-nom>

Please submit your nomination electronically, preferably in PDF format, to [apaward@cms.math.ca](mailto:apaward@cms.math.ca).

### Nomination requirements:

- Include contact information for both nominee and nominator.
- Describe the nominated individual's or team's sustained contributions to mathematics education. This description should provide some indication of the time period over which these activities have been undertaken and some evidence of the success of these contributions. This information must not exceed four pages.
- Two letters of support from individuals other than the nominator should be included with the nomination.
- Curricula vitae should not be submitted since the information from them relevant to contributions to mathematics education should be included in the nomination form and the other documents mentioned above.
- If nomination was made in the previous year, please indicate this.
- Members of the CMS Education Committee will not be considered for the award during their tenure on the committee.

### Renewals

Individuals who made a nomination last year can renew this nomination by simply indicating their wish to do so by the deadline date. In this case, only updating materials need be provided as the original has been retained.

## Appel de mises en candidature – Prix Adrien Pouliot

Nous sollicitons la candidature de personne ou de groupe de personnes ayant contribué d'une façon importante et soutenue à des activités mathématiques éducatives au Canada. Le terme « contributions » s'emploie ici au sens large ; les candidats pourront être associés à une activité de sensibilisation, un nouveau programme adapté au milieu scolaire ou à l'industrie, des activités promotionnelles de vulgarisation des mathématiques, des initiatives, spéciales, des conférences ou des concours à l'intention des étudiants, etc.

Les mises en candidature doivent parvenir au bureau de la SMC avant le **30 avril 2016**. Pour plus de renseignements, voir : <https://cms.math.ca/Prix/ed-cand.html>

Veuillez faire parvenir votre mise en candidature par voie électronique, de préférence en format PDF, à [prixap@smc.math.ca](mailto:prixap@smc.math.ca).

### Conditions de candidature

- Inclure les coordonnées du/des candidat(s) ainsi que le(s) présentateur(s).
- Décrire en quoi la personne ou le groupe mise en candidature a contribué de façon soutenue à des activités mathématiques. Donner un aperçu de la période couverte par les activités visées et du succès obtenu. La description ne doit pas être supérieur à quatre pages.
- Le dossier de candidature comportera deux lettres d'appui signées par des personnes autres que le présentateur.
- Il est inutile d'inclure des curriculums vitae, car les renseignements qui s'y trouvent et qui se rapportent aux activités éducatives visées devraient figurer sur le formulaire de mise en candidature et dans les autres documents énumérés ci-dessus.
- Si la mise en candidature a été soumise en l'année précédente, s'il vous plaît indiquez-le.
- Les membres du Comité d'éducation de la SMC ne pourront être mise en candidature pour l'obtention d'un prix pendant la durée de leur mandat au Comité.

### Renouveler une mise en candidature

Il est possible de renouveler une mise en candidature présentée l'an dernier, pourvu que l'on en manifeste le désir avant la date limite. Dans ce cas, le présentateur n'a qu'à soumettre des documents de mise à jour puisque le dossier original a été conservé.

## CJM Editors-In-Chief



The CMS invites expressions of interest for the Editors-In-Chief (EIC) of the CJM; **two EICs are being solicited, with a term scheduled to commence January 1, 2017.** Funding support from the CMS is available for both these EIC positions.

Since 1949, the **Canadian Journal of Mathematics** has been committed to publishing original mathematical research of high standard following rigorous academic peer review. New research papers are published continuously online and are collated into print issues six times each year.

Expressions of interest should include a cover letter, your curriculum vitae, and an expression of views regarding the publication. Since being EIC of CJM is a large responsibility that may require a lessening of responsibilities in an individual's normal work, individuals should review their candidacy with their university department and include a letter of support.

Please submit your expression of interest electronically to: **CJM-EIC-2015@cms.math.ca** before **May 15, 2016**.

### Current CJM/CMB Editorial Board

Henry Kim (Toronto)	12/2016	Editor-in-Chief CJM
Robert McCann (Toronto)	12/2016	Editor-in-Chief CJM
Jie Xiao (Memorial)	12/2019	Editor-in-Chief CMB
Xiaoqiang Zhao (Memorial)	12/2019	Editor-in-Chief CMB
Louigi Addario-Berry (McGill)	12/2018	Associate Editor
Jason Bell (Waterloo)	12/2020	Associate Editor
Hans Boden (McMaster)	12/2020	Associate Editor
Alexander Brudnyi (Calgary)	12/2020	Associate Editor
Florin Diacu (Victoria)	12/2016	Associate Editor
Ilijas Farah (York)	12/2020	Associate Editor
Ailana Fraser (UBC Vancouver)	12/2020	Associate Editor
Skip Garibaldi (UCLA)	12/2016	Associate Editor
Dragos Ghioca (UBC Vancouver)	12/2018	Associate Editor
Eyal Goren (McGill)	12/2018	Associate Editor
Robert Leon Jerrard (Toronto)	12/2016	Associate Editor
Anthony To-Ming Lau (Alberta)	12/2016	Associate Editor
Alexander Litvak (Alberta)	12/2016	Associate Editor
Javad Mashreghi (Laval)	12/2020	Associate Editor
Marco Merkli (Memorial)	12/2020	Associate Editor
Assaf Naor (Princeton)	12/2018	Associate Editor
Erhard Neher (Ottawa)	12/2016	Associate Editor
Nilima Nigam (Simon Fraser)	12/2020	Associate Editor
McKenzie Wang (McMaster)	12/2016	Associate Editor
Juncheng Wei (UBC Vancouver)	12/2018	Associate Editor
Daniel Wise (McGill)	12/2018	Associate Editor
Efim Zelmanov (UCSD)	12/2016	Associate Editor

## Rédacteurs en chef pour le JCM

La SMC invite les personnes intéressées par un poste de rédacteurs en chef au JCM à lui faire part de leur intérêt. **Deux postes de rédacteurs en chef sont à pourvoir, pour un mandat qui commencera le 1 janvier 2017.** La SMC offre du soutien financier pour ces deux postes.

Depuis 1949, le **Journal Canadien de Mathématiques** s'engage à publier des recherches en mathématiques, originales et de haut niveau, suivant de rigoureux examens par des pairs. Les articles de recherches sont disponibles en tout temps en ligne et sont rassemblés en six éditions imprimées par année.

Les propositions de candidature comprendront les éléments suivants : une lettre de présentation, votre curriculum vitae et un texte dans lequel vous exprimez votre opinion et vos idées par rapport à la publication. Puisque devenir rédacteur en chef de la JCM est une grande responsabilité qui peut nécessiter une réduction dans la charge normale de travail, les individu(e)s devraient vérifier leur candidature avec leur département et veuillez ajouter une preuve du soutien.

Veuillez faire parvenir votre candidature par courriel à : **CJM-EIC-2015@smc.math.ca** au plus tard le **15 mai 2016**.

### Conseil de rédaction pour le JCM et le BCM à présent :

Henry Kim (Toronto)	12/2016	Rédacteur en chef du JCM
Robert McCann (Toronto)	12/2016	Rédacteur en chef du JCM
Jie Xiao (Memorial)	12/2019	Rédacteur en chef du JCM
Xiaoqiang Zhao (Memorial)	12/2019	Rédacteur en chef du JCM
Louigi Addario-Berry (McGill)	12/2018	Rédacteur associé
Jason Bell (Waterloo)	12/2020	Rédacteur associé
Hans Boden (McMaster)	12/2020	Rédacteur associé
Alexander Brudnyi (Calgary)	12/2020	Rédacteur associé
Florin Diacu (Victoria)	12/2016	Rédacteur associé
Ilijas Farah (York)	12/2020	Rédacteur associé
Ailana Fraser (UBC Vancouver)	12/2020	Rédactrice associée
Skip Garibaldi (UCLA)	12/2016	Rédacteur associé
Dragos Ghioca (UBC Vancouver)	12/2018	Rédacteur associé
Eyal Goren (McGill)	12/2018	Rédacteur associé
Robert Leon Jerrard (Toronto)	12/2016	Rédacteur associé
Anthony To-Ming Lau (Alberta)	12/2016	Rédacteur associé
Alexander Litvak (Alberta)	12/2016	Rédacteur associé
Javad Mashreghi (Laval)	12/2020	Rédacteur associé
Marco Merkli (Memorial)	12/2020	Rédacteur associé
Assaf Naor (Princeton)	12/2018	Rédacteur associé
Erhard Neher (Ottawa)	12/2016	Rédacteur associé
Nilima Nigam (Simon Fraser)	12/2020	Rédactrice associée
McKenzie Wang (McMaster)	12/2016	Rédacteur associé
Juncheng Wei (UBC Vancouver)	12/2018	Rédacteur associé
Daniel Wise (McGill)	12/2018	Rédacteur associé
Efim Zelmanov (UCSD)	12/2016	Rédacteur associé

## Call for Nominations – CMS Research Prizes

The CMS Research Committee is inviting nominations for three prize lectureships. These prize lectureships are intended to recognize members of the Canadian mathematical community.

The **Coxeter-James Prize** Lectureship recognizes young mathematicians who have made outstanding contributions to mathematical research. The recipient shall be a member of the Canadian mathematical community. Nominations may be made up to ten years from the candidate's Ph.D. A nomination can be updated and will remain active for a second year unless the original nomination is made in the tenth year from the candidate's Ph.D. For more information, visit: <https://cms.math.ca/Prizes/cj-nom>

The **Jeffery-Williams Prize** Lectureship recognizes mathematicians who have made outstanding contributions to mathematical research. The recipient shall be a member of the Canadian mathematical community. A nomination can be updated and will remain active for three years. For more information: <https://cms.math.ca/Prizes/jw-nom>

The **Krieger-Nelson Prize** Lectureship recognizes outstanding research by a female mathematician. The recipient shall be a member of the Canadian mathematical community. A nomination can be updated and will remain active for two years. For more information: <https://cms.math.ca/Prizes/kn-nom>

The deadline for nominations is **June 30, 2016**.

Nominators should ask at least three referees to submit letters directly to the CMS by September 30, 2016. Some arms-length referees are strongly encouraged. Nomination letters should list the chosen referees, and should include a recent curriculum vitae for the nominee, if available. Nominations and reference letters should be submitted electronically, preferably in PDF format, by the appropriate deadline to the corresponding email address:

Coxeter-James: [cjprize@cms.math.ca](mailto:cjprize@cms.math.ca)

Jeffery-Williams: [jwprize@cms.math.ca](mailto:jwprize@cms.math.ca)

Krieger-Nelson: [knprize@cms.math.ca](mailto:knprize@cms.math.ca)

## Appel de mises en candidature – Prix de recherche de la SMC

Le Comité de recherche de la SMC lance un appel de mises en candidatures pour trois de ses prix de conférence. Ces prix ont tous pour objectif de souligner l'excellence de membres de la communauté mathématique canadienne.

Le **Prix Coxeter-James** rend hommage aux jeunes mathématiciens qui se sont distingués par l'excellence de leur contribution à la recherche mathématique. Cette personne doit être membre de la communauté mathématique canadienne. Les candidats sont admissibles jusqu'à dix ans après l'obtention de leur doctorat. Toute mise en candidature est modifiable et demeurera active l'année suivante, à moins que la mise en candidature originale ait été faite la 10<sup>e</sup> année suivant l'obtention du doctorat. Pour les renseignements, voir : <https://cms.math.ca/Prix/cj-nom>

Le **Prix Jeffery-Williams** rend hommage aux mathématiciens ayant fait une contribution exceptionnelle à la recherche mathématique. Cette personne doit être membre de la communauté mathématique canadienne. Toute mise en candidature est modifiable et demeurera active pendant trois ans. Pour les renseignements, voir : <https://cms.math.ca/Prix/jw-nom>

Le **Prix Krieger-Nelson** rend hommage aux mathématiciennes qui se sont distinguées par l'excellence de leur contribution à la recherche mathématique. La lauréate doit être membre de la communauté mathématique canadienne. Toute mise en candidature est modifiable et demeurera active pendant deux ans. Pour les renseignements, voir : <https://cms.math.ca/Prix/info/kn>

La date limite de mises en candidature est le **30 juin 2016**.

Les proposants doivent faire parvenir trois lettres de référence à la SMC au plus tard le 30 septembre 2016. Nous vous incitons fortement à fournir des références indépendantes. Le dossier de candidature doit comprendre le nom des personnes données à titre de référence ainsi qu'un curriculum vitae récent du candidat ou de la candidate, dans la mesure du possible. Veuillez faire parvenir les mises en candidature et lettres de référence par voie électronique, de préférence en format PDF, avant la date limite, à l'adresse électronique correspondante:

Coxeter-James : [prixcj@smc.math.ca](mailto:prixcj@smc.math.ca)

Jeffery-Williams : [prixjw@smc.math.ca](mailto:prixjw@smc.math.ca)

Krieger-Nelson : [prixkn@smc.math.ca](mailto:prixkn@smc.math.ca)

If undelivered, please return to:

Si NON-LIVRÉ, veuillez retourner à :

CMS Notes / Notes de la SMC

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