



math circles

Annual Report 2020–2021

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Mission Statement

Nova Scotia Math Circles is dedicated to enriching the experiences of Nova Scotia students in all areas of mathematics.

Our program vision is to foster enthusiasm for math through interactive, creative, and meaningful presentations.

Many thanks to our sponsors!





Nova Scotia Math Circles is a mathematics outreach program run out of Dalhousie University and funded by Eastlink. Our activities are two-fold: We host monthly events at Dalhousie to enrich local students and visit schools all across the province for hands-on activities with the entire class.

Overview

Despite challenges presented by the pandemic, Nova Scotia Math Circles continued its extreme success in the 2020–2021 academic year.

Thanks to the ongoing funding from Eastlink, we were able to continue our outreach to students across Nova Scotia by adapting to online learning formats, while simultaneously focusing on professional development to allow us to continue to offer excellent educational opportunities.

This year we had lots of change in our program at the personnel level: Dr. Mayada Shahada left to pursue a post-doctoral position, while Tom Potter became interim program director of Math Circles. Tom is currently pursuing a Ph.D. in mathematics at Dalhousie and was a presenter and content developer for Math Circles for two years prior to taking on this role. Dr. David Iron was our faculty advisor this year and helped by giving Tom feedback and support through challenges faced this year. Several students in our department joined or continued with Math Circles: Heesung Yang continued as a presenter and content developer for Math Circles, and Mozghan Saeidi continued as a presenter: it is Heesung's second year with us, and Mozghan's third. Dario Brooks joined us as a presenter, and Justin Makary initiated our monthly events by giving the first workshop and helping organize it. Just recently, Sarah Li has joined our team as a presenter.

We began differently this year, with brainstorming, planning, and training before beginning visits to classes. Many of our activities relied heavily on hands-on learning with materials that were brought to classes. We had to figure out how to adapt these to online formats, as the pandemic meant only essential visitors were allowed in schools. We chose some of our most popular presentations to adapt and have added to these throughout the year. When schools were closed at the end of April and through May, we found ways to present activities entirely online, through Google Meet or Zoom.

Because of the intensive work of adapting presentations and the scheduling challenges with this new format, it was not feasible to do our usual week-long trips this year. We expect, however, that our virtual presentations will make it possible to reach an even broader audience across Nova Scotia in future years.

We shifted our approach this year from School Visits to Class Visits. By the end of May we reached 1084 students through virtual class visits, with 45 class visits in total and another 30+ visits planned for June. We have (virtually) visited public and private schools in the HRM, in Annapolis Valley, and in the Colchester County district. Now that we have done the hard work of adapting to a new format, it will be easier going forward to reach a larger number of students and broaden our outreach to include more communities. We also look forward to resuming our in-person activities as soon as possible.

Each of our eight online Monthly evening events attracted a mix of participants from students, parents, and teachers. These events were given by presenters from our team, enthusiastic undergraduate and graduate students, department alumni, and post-doctoral researchers in our department. A total of 158 students joined us via Zoom or Teams, and we have one more event planned for June. We again thank our volunteers for giving these fun workshops. See pages 6 - 8 for a list of presenters and top-

ics.

This year we added two exciting new presentations to our repertoire: Candy Game and Pascal's Triangle. We also expanded our training to facilitate moving to the online format, and to master the growing number of presentations. We created a guide for presenting virtually, to ensure our presentation quality remains high, and have made improvements to our existing presentations. We updated our operations manual and our website, created all new webforms with spam protection, and participated in the WISEatlantic STEM Spotlight Series and Partnerships Workshop.

Future goals include resuming in-person activities and week-long trips, expanding our social media presence, doing more to reach underrepresented groups, reaching a more geographically diverse audience across the province, recruiting French-speaking presenters, continuing to expand our training and professional development, and much more! See page 11 for a more detailed description of future goals.

This year, Math circles celebrates its seventh year of funding with Eastlink. Thank you, Eastlink, you've made our success possible!



“The Math Circles presentation was very well received. The students were engaged and loved the challenges presented. Several students even said, “this is the best math class I’ve ever had!” Thank you so much for your creativity, passion for math, and positive responses to the students. We had a great time, and learned a lot!”—Sara Boone, Truro Junior High School

List of Presentations

Elementary Schools

- Candy Game (New)*
- Dots and Boxes*†
- Exploding Buckets*
- Exploring Mathematics*
- Jury Duty*
- Fun with Fractions*
- Mathemagic*
- Pascal's Triangle (New)*
- Pentominoes
- Problem Solving*
- Tessellations*†

* These presentations have been adapted for virtual class visits.

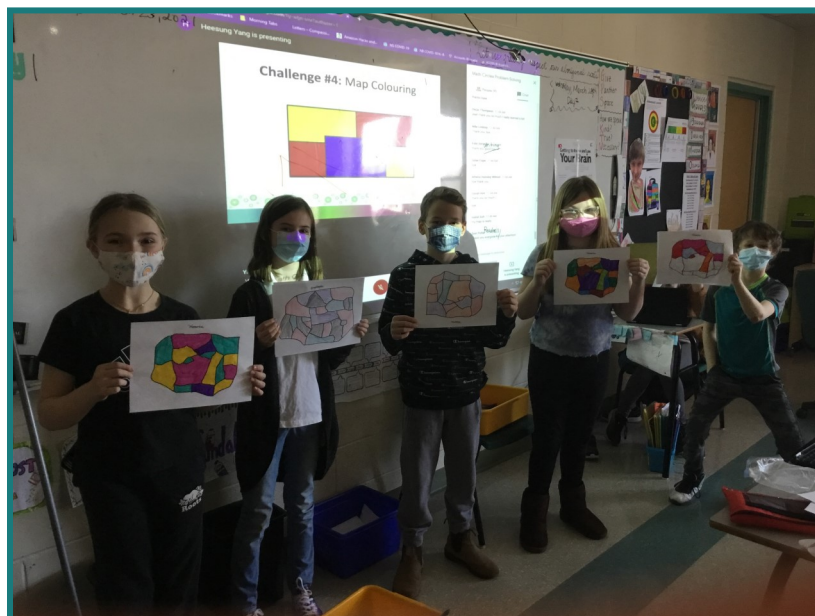
† These presentations have undergone revisions and improvements.

Junior High Schools

- Bothersome Brainteasers*
- Candy Game (New)*
- Classical Cryptography
- Dots and Boxes*†
- Eulerian Circuits
- Fibonacci & the Golden Ratio†
- Fractions Fun
- Graph Colouring
- Jury Duty*
- Mathemagic*
- Nasty Number Tricks and Devious Divisibility
- Pascal's Triangle (New)*
- Prime Numbers
- Problem Solving*
- Tessellations*†
- Toads and Frogs*
- Tower of Hanoi

Senior High Schools

- Bothersome Brainteasers*
- Classical Cryptography
- Eulerian Circuits
- Fibonacci & the Golden Ratio†
- Fractals
- Graph Colouring
- Infinity
- Logic and Reasoning
- Million Dollar Hat Problem
- Master Your Cards
- Modern Cryptography
- Nasty Number Tricks and Devious Divisibility
- Nim
- Numeral Systems
- Pascal's Triangle (New)*
- Permutations & Combinations
- Pi
- Prime Numbers
- Toads and Frogs*
- Tower of Hanoi



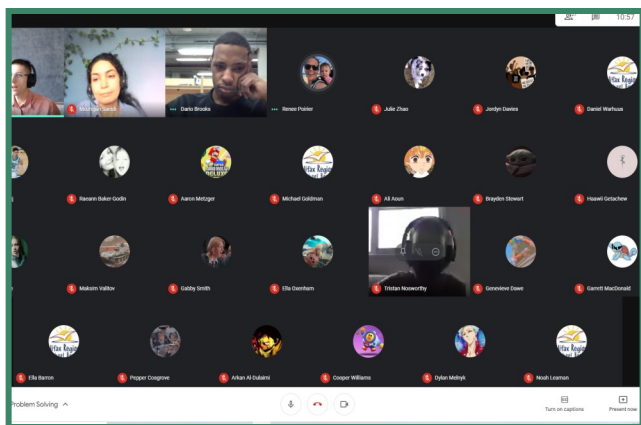
NS Math Circles Staff

Program Director

The Program Director is responsible for the day-to-day running of Math Circles. The Director oversees the overall program direction and the school trips, online class visits, local, online, and other events. They are also responsible for the social media and newsletter.

This year, the Program Director was Tom Potter, a Ph.D. candidate in the department. Tom is new to this position, after being a presenter and content developer for NS Math Circles for two years under the direction of Dr. Mayada Shahada.

Faculty Advisor



The faculty advisor is the liaison between Math Circles and the Mathematics & Statis-

"I loved your presentations! The kids were interested, curious and engaged and they really got a lot out of them. Thank you!" —M. Snow, Maple Grove Education Centre, Yarmouth.

tics Department. This person also provides continuity as they usually stay in this position for several years. They advise the Director and any Assistant Directors on any issues that might arise.

This year, Dr. David Iron was our faculty advisor.

Presenters and Content Developers

The presenter/content developer positions are filled by graduate students who commit to working with Math Circles throughout the year for a significant number of hours. They staff many of our school/class visits and develop and update presentations. Our presenter/content developers this year were Heesung Yang and Dario Brooks, who are both Ph.D. students in our department.

Casual Presenters

The casual presenters are undergraduates and graduate students, and postdoctoral fellows at Dalhousie that will occasionally go out on school trips or help with class visits. This year, our casual presenters were Mozghan Saeidi, and more recently Sarah Li. Mozghan is a Ph.D. student in Computer Science at Dalhousie, and Sarah just recently finished her Honours degree in our department.



Monthly Events

This year we hosted 8 virtual evening events, with approximately 160 students in total in attendance. We have one more event scheduled for June 9.

October 28th Presenter: Justin Makary (Dalhousie)

Topic: Wonders of the Infinite

The concept of infinity has both interested, and bewildered mathematicians over the course of history. We explore some interesting properties of infinity that are not so obvious. For example, a hotel with infinitely many rooms all which are filled, can still accommodate new guests (Known as Hilbert's Hotel). A lab with infinitely many monkeys typing on keyboards, would eventually produce all of the works of Shakespeare. We consider these interesting properties through the use of examples, in an interactive work session.

November 25th Presenter: Tom Potter (Dalhousie)

Topic: Interactive Problem Solving

Problem solving is central to mathematics. In this presentation we will interactively tackle a series of fun problems, and students will be encouraged to attempt their own solutions and share their ideas with us. We will also very briefly discuss the recent history of approaches to problem solving, including concepts like: can you become a better problem solver? what are common pitfalls? what constitutes a real problem? and what about problem posing? These problems will be geared toward a junior high level audience. Have your pencil and paper ready!

December 16th Presenter: Heesung Yang (Dalhousie)

Topic: Pascal's Triangle

Pascal's triangle is an array of numbers arranged in a triangular shape which, upon

Well paced ... Students were engaged and eager to share their insights :)
- B. Vaughan, Halifax Central Junior High school, Halifax.

closer inspection, contains fascinating patterns. In this presentation we will explore what information Pascal's triangle contains and discover that it has connections to combinatorics ("art of counting"), number theory, geometry and even fractals. We will end with an idea that seems true, intuitively, but is surprisingly not yet proven.

January 27th Presenter: Sarah Meng Li (Dalhousie)

Topic: Logic and Puzzles

In school, we learned that math is a set of rules, and we were trained to become human calculators. Admittedly, number sense is important, but math is not just computation. Mathematical thinking is a way of observing and understanding the world. Math allows us to see hidden order in real world chaos!

This workshop will introduce you to another aspect of Mathematics, logic. We will show you how to use mathematical thinking to solve problems, identify the hidden patterns, and think like a mathematician. From solving math puzzles, you will develop your logical reasoning and critical thinking skills.

February 24th Presenter: Dr. Frank Fu (Dalhousie)

Topic: Fun with Cryptography

How do we communicate through the internet without being eavesdropped? How can we login to a remote computer without using a password? How does the remote computer know it is really me? In this talk, we will learn a few cryptographic concepts and encryption methods. Hopefully, by the end of the talk, we gain some insights into how modern cryptography is safeguarding the digital world.

March 31st Presenter: Dr. Asmita Sodhi (Dalhousie)

Topic: Exploding Dots

Imagine you have constructed a curious mathematical machine, which consists of several boxes in a row. When you put one dot in the first box, nothing happens. But when you add another dot to the box... BOOM! These two dots explode, and form a new dot in the second box. When we put a second dot in that box to join the first... BOOM! These dots explode too, and form a new dot in the third box. What will happen if we make some changes to our machine, so now we need to add three dots for an explosion? Or more? What mathematics can we learn from this strange machine? In this talk, we'll learn about different ways of counting and arithmetic ideas while playing with Exploding Dots.

This talk will make use of the online [Mathigon Polypad](#) so that you can interact with the dots yourself. If you can, please make sure you can either access the Polypad from the same device you're using to join the talk, or a different one! Links to pre-made Polypads to play on will be shared during the talk.

April 28th Presenter: Dr. Matthew Amy (Dalhousie)

Topic: The Secret of Nim

Can mathematics help us to win games? Quite unlike the NIMH from the 1980's animated fantasy film after which this workshop is named, Nim is an ancient game with a deep mathematical theory. In this workshop we will explore the game of Nim and learn to use the mathematics of binary numbers to outsmart our opponents. Next we will look at the even more devious hat game where we can stack the odds in our favour,



again through the magic of binary numbers. Finally, we will learn how these principles are used to protect our precious data from harmful rays of sunlight and other sources of errors.

May 26th Presenter: Sarah Meng Li (Dalhousie)

Topic: Math and Coding

Believe it or not, coding is full of math. In real life, coding is used to implement an algorithm, a recipe to solve a logical and mathematical problem. But coding can do

The presentation was at the right level—therefore, students were engaged and able to make some connections to our curriculum - J. Steele, Rocky Lake Jr. High School, Bedford.

more than that. It is an engaging way to learn math and it will help you develop an intuition for abstract theories.

In this workshop, let's think and experience math in a hands-on, dynamic, and engaging way! You will soon be amazed by the project you have developed with your friends and how much you have learned from it.

We will use Scratch, a block-based visual programming language and website developed by MIT Media lab. On this platform, you will develop your first Scratch project such as Lattice Multiplication, Calculator, Geometric Kaleidoscope, and Drawing Shape with Math. You can even program an interactive animation to teach some interesting math problems.

At the end of the workshop, you are welcomed to share your work. If you wish, you could also share it on the Scratch platform with people around the world!

June 9th Presenters: Sarah Li and Mozghan Saeidi

Topic: Problem Solving and Algorithms

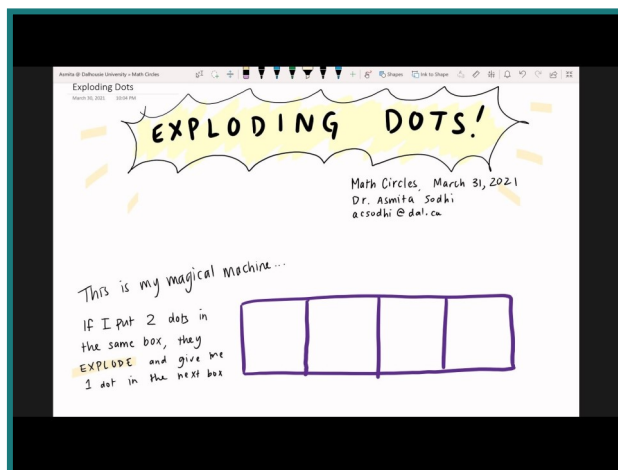
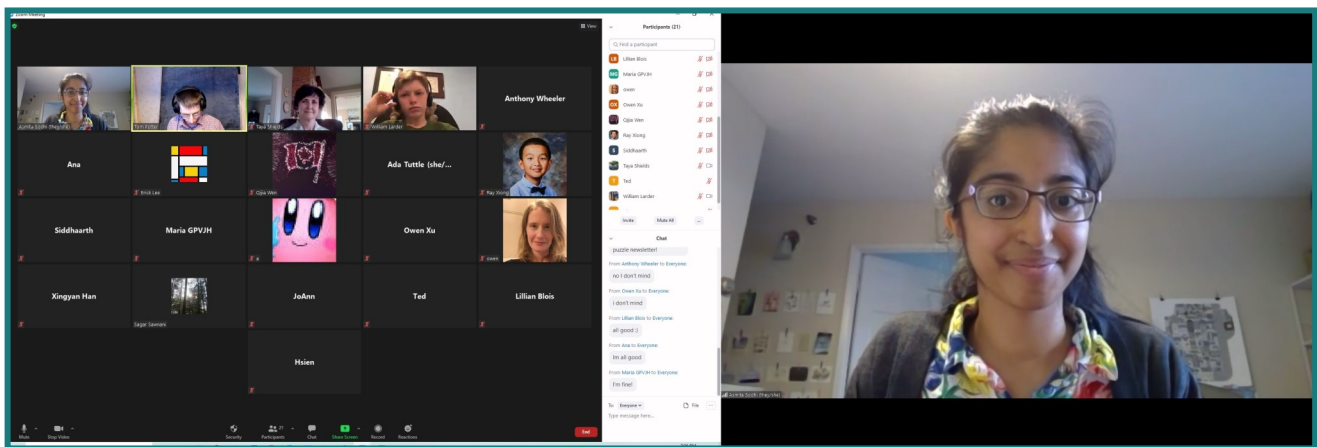
□ Divide-and-conquer algorithm

- Four-colourability of the world map
- Circular maximum sum subarray problem

- Euclidean algorithm
 - Continued fractions
- Karatsuba's algorithm
 - Multiplication of integers
 - Lattice multiplication

“Thank you for providing such great enrichment for students in math. Our students benefit from the content of each seminar and also the interesting ways of thinking about problem solving.”

—Taya Shields, Junior School Director, King’s-Edgehill School.



School and Program Events and Activities

Week-long trips

We regret that this year it was not feasible to do week-long trips, due to staffing challenges and the nature of scheduling individual classes as opposed to school visits. We look forward to resuming our week-long trips when schools reopen to visitors.

Materials' Development

We made a strong effort this year to improve the quality of our presentations, along with the PowerPoint slides that we rely on for these. When we introduced two new presentations, we tested them out with our virtual class visits and immediately used that experience to improve them, based on teacher feedback and our own perceptions. Many of our older presentations could benefit from updates, and we were able to accomplish this for a number of them. One of the most substantial developments we made this year we revising our presentations in creative ways to do math outreach virtually. With the help of tablets, document cameras, and excellent teachers, this was a success. There are more topics we look forward to including in future years, including Math and Coding, and some Game Theory related to the game Set.

Training and Professional Development

Much of our focus this year was on learning the technology and skills needed to present online. This involved lots of practice! We put together a guide for presenting virtually in the future, which deals with issues of audio feedback in classrooms, communication skills, managing multiple windows when presenting, and efficient use of tablets. Also,



with a growing number of presentations, it becomes increasingly important to devote time to training.

Other Activities

In the Spring of this year, our Director participated in a Partnership event hosted by WISEatlantic, to discuss organizational best practices, outreach (to equity-deserving groups and to parents/teachers), partnerships, (new partnerships, strengthening existing ones), and problem solving/overcoming challenges. We also submitted a summary description our program for WISEatlantic's STEM Spotlight series—this can be found on their webpage.

“Thank you for your visits this year, they were a highlight for our students.”—Stephanie Sajatovich, Middle School Director, Armbrae Academy

This year we were able to reach schools in 3 different centres for education (school boards):

Halifax Regional Centre for Education (HRCE)

Brookhouse Elementary (2 visits), École Burton Ettinger (15 Visits), Colonel John Stuart Elementary (1 visit), Harold T Barrett Jr High (4 visits), Portland Estates Elementary (1 visit), Rockingham School (2 visits), Sir Charles Tupper Elementary (3 visits). In June we have nearly 30 class visits planned, including visits to Tantallon Senior Elementary, Ocean View Elementary, Sir Charles Tupper, and Rockingham School.

Annapolis Valley Regional Centre for Education (AVRCE)

Kingston and District School (1 visit), Pine Ridge Middle School (4 visits)

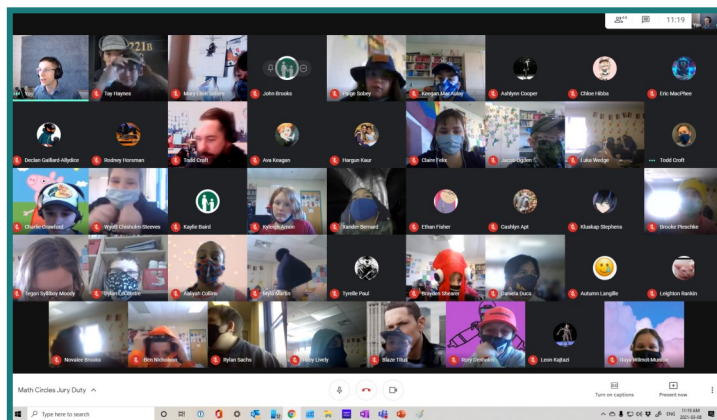
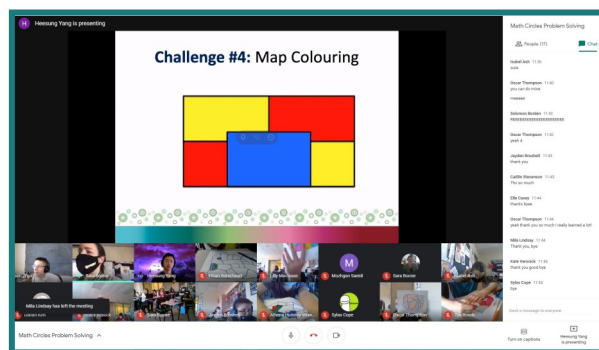
Chignecto-Central Regional Centre for Education (CCRCE)

Truro Junior High School (6 visits)

Private Schools/Groups

Armbrae Academy (4 visits), Halifax Grammar School (2 visits)

“Both facilitators were very friendly and engaging and excited about the material.”—Charlotte Fillmore, Armbrae Academy



math circles
Join in the fun today!

Mathematical Jury Duty

A look at logic, graph theory, geometry & number theory

2021-2022 Program Goals

We will continue our strong presence in schools during 2021-2022. Future goals include:

- resuming in-person activities and week-long trips
- increasing interest in our program through greater social media presence
- expanding and revitalizing our Newsletter
- doing more to reach underrepresented groups
- reaching a more regions across the province
- forming partnerships with other outreach programs
- recruiting French-speaking presenters

- adding presentations on Math and Coding, as well as Game Theory
- and much more!



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