

BUILDING BRIDGES TO SUCCESS

CENTRE FOR EDUCATION IN
MATHEMATICS AND COMPUTING



UNIVERSITY OF
WATERLOO



The CENTRE for EDUCATION in
MATHEMATICS and COMPUTING

LETTER FROM THE DIRECTOR

IAN VANDERBURGH





Last year, I came to work one day to find an email in my inbox from a secondary-school student who had reached out to share the tremendous role mathematics and computer science had played in his life. He also passed along his gratitude to us at the Centre for Education in Mathematics and Computing (CEMC) for helping to make that possible – for, in his words, inspiring young people to dig a little deeper, think a little harder and possibly even make big changes in the world someday.

What an email! As I reflect on 2021, this note comes to mind, along with many other messages sent by teachers and students sharing kind words and wonderful insight. I am so grateful to our community of supporters, friends, volunteers and champions for making this work possible.

The past year has seen the dedicated staff and faculty at the CEMC continue the work we began the year before to ensure that students and teachers could access many of our programs and resources from wherever they work and learn – whether that be in the classroom or in homes around the world. It was also a year of renewed growth and exciting new ventures.

One area in which we've seen significant growth is in our computing events. Interest among young people in computing is on the rise, and we're happy to help meet that interest with events and resources that can help students translate this interest into a deeper familiarity with computational thinking, coding, and the less technical aspects of computer science, as well as increased confidence in their abilities. From our new CS Escape workshop to the Canadian Computing Competition and resources and opportunities designed for computer science teachers – all of which you'll learn more about in this report – we're dedicated to connecting young people to meaningful, fun opportunities to grow their love of computer science.

This year, I am also happy to share the success of new partnerships in Africa. As one aspect of this work, my colleagues and I feel very fortunate for the chance to participate in Girls in Mathematical Sciences Program hosted by the African Institute for Mathematical Sciences centre in Ghana, as mentors and instructors to a group of incredibly bright young students. The CEMC is committed to supporting mathematics and computer science education in Africa; you can learn about the program and hear from the students themselves in this report.

On behalf of everyone at the CEMC, I want to extend our gratitude for your support of the work that we do and for championing mathematics and computer science education. I hope that the stories shared in this report give you a snapshot of what that support means for students around the world.

IAN VANDERBURGH
DIRECTOR, CEMC

HELPING GIRLS IN GHANA LEAD THE CHARGE IN MATHEMATICS AND TECHNOLOGY

AN INTERNATIONAL COLLABORATION IN GHANA IS SPARKING EXCITEMENT AMONG STUDENTS AND EDUCATORS ABOUT THE FUTURE OF STEM.

BY LISA KABESH

The Centre for Education in Mathematics and Computing (CEMC) has partnered with the African Institute for Mathematical Sciences (AIMS) to support its innovative Girls in Mathematical Sciences program.

The nine-month program brings young women together from across Ghana's 16 regions to dive deep into how math and technology can solve big problems — in Ghana and across Africa. Driven by the goal to empower talented female secondary-school students to lead cutting-edge research and innovation in the years to come, the program connects participants with international scientists, university educators and industry leaders.

The CEMC has lent its support with the expertise and experience the organization brings with its long tenure of mathematical and computer science outreach education. Ian VanderBurgh, the CEMC's director, led 10 sessions focused on problem-solving and Serge D'Alessio and Judith Koeller each led an intensive master class. The CEMC's Comfort Mintah led fireside discussions with six other women from different fields to introduce participants to the wide array of education and career paths available to them. All four members of the CEMC team committed to mentoring participants throughout the nine-month program.

Mintah was impressed with the students' development: "I didn't even know what I wanted to be in high school. After the Girls in Mathematical Sciences program, the students were excited about careers in data analysis and engineering thanks to the program. It helps students see amazing opportunities for their potential at an early age."

Senior high-school student Dzesisenu Yetorgbe Adzomani explained that the program pushed her "to develop an inquiring mind and strong curiosity about science and nature," which she plans to bring to bear on the study of architectural engineering. "I believe that greatness comes from the desire to do extraordinary things," she added, and said that she is "driven to strive for greatness and to pursue the AIMS goal of becoming the next Einstein."

Georgina Amoasi, a participant from the central region of Ghana, said: "AIMS has helped me to realize that mathematical approaches can provide a vast array of solutions to the same problem." Her current interests lie in improving decision-making with data research and technology. Georgina is planning a career in data analysis; other students foresee studies in physics in their futures, while others aspire to work in fields like the health sciences.

As part of the program, participants met online each month through much of 2021, where they developed creative, meaningful problem-solving skills and made connections between mathematical sciences and the real world. Two week-long, in-person residential components allowed students to tackle team projects and build deeper connections with their instructors and mentors.

Lois Agbemavi, another student participant, summed up the program neatly: "For girls in STEM, I believe that AIMS is definitely where ability meets opportunity."



"AIMS HAS HELPED ME TO REALIZE THAT MATHEMATICAL APPROACHES CAN PROVIDE A VAST ARRAY OF SOLUTIONS TO THE SAME PROBLEM. THIS IDEA HAS BECOME AN INTEGRAL ASPECT OF MY EDUCATION."

- GEORGINA AMOASI, PARTICIPANT

INSPIRING GROWTH, MAKING SPACE AND NURTURING CURIOSITY IN COMPUTER SCIENCE

HOW THE CEMC IS BUILDING PROGRAMMING AND RESOURCES TO ENSURE A DIVERSE AND RESPONSIBLE FUTURE FOR COMPUTING

BY LISA KABESH

At the Centre for Education in Mathematics and Computing (CEMC), teachers and parents can find computer science resources and opportunities for students as young as 10 years old. And yet, for many people, the second “C” in the CEMC is not as well-known as the “M.”

According to the Government of Canada, job growth in the information and communication technologies (ICT) sector has outpaced that of the Canadian economy for many years. Employment growth in software and computing in particular has nearly doubled the growth of the ICT sector overall. Projections show employment in computing fields continuing to expand faster than the national average.

Rapid innovation and technological advances are driving this growth — and so, too, are they driving a surge of interest in computing among young people.



“THE EXPERIENCE OF MEETING OTHER GIRLS BOTH WITHIN CANADA AND ACROSS THE WORLD HAS REALLY GIVEN ME A DISTINCT SENSE OF COMMUNITY.”

– SOPHIE XUAN,

PARTICIPANT, EUROPEAN GIRLS' OLYMPIAD IN INFORMATICS

The CEMC is meeting that interest with a suite of resources and events designed to help students expand their knowledge of computing and its applications, all while building their confidence and sparking their curiosity about what they can achieve with computer science. One such resource is Computer Science Circles, a series of free, interactive lessons teaching the basics of writing computer programs in Python for beginners.

But at the CEMC, it's not only about learning how to code.

The Beaver Computing Challenge, for example, introduces students with little or no previous experience with programming to computer science. Here the emphasis isn't on coding, but on thinking like a computer scientist.

“A good question for the Beaver Computing Competition (BCC) is one that gets students excited about computer science. It's also one that genuinely involves computational thinking,” says J.P. Pretti, co-lead of the BCC at the CEMC. Pretti defines computational thinking as the process of formulating and solving problems by breaking them down into simple steps. Nurturing this skill lays the foundation for students to see themselves in computing; it also helps them see the real-world impact computing can have.

INSPIRING GROWTH

Two annual CEMC contests give students the chance to challenge their computing skills even further. Designed to be accessible to students with some programming experience and to challenge the strongest programmers at the secondary-school level, the Canadian Computing Competition helps students build confidence and develop their ability to design, understand and implement algorithms.

Roughly 20 of the top CCC senior participants are invited to the CEMC's Canadian Computing Olympiad (CCO), a week-long event involving workshops, a contest and other extra-curricular activities that also prepares students for participation in the prestigious International Olympiad in Informatics.

2021 also saw a team representing Canada in the inaugural European Girls' Olympiad in Informatics. Led by the CEMC, the team of four young women brought home bronze medals for Canada and a renewed confidence in their abilities.

Sophie Xuan, a Team Canada representative, emphasized the sense of belonging that EGOI afforded her. “The experience of meeting other girls both within Canada and across the world has really given me a distinct sense of community,” she said.



MAKING SPACE

Fostering a sense of belonging among girls and people of other underrepresented genders in STEM is an important focus of the CEMC's computer science programming.

Two workshops in particular, make space for skill development and confidence building among girls and people of other genders who don't often see themselves represented in STEM: CS Escape and Seeing Possibilities and Rewards in Computer Science (SPARCS).

Designed for students who are new to programming, CS Escape prepares participants to embark on their own programming project — a virtual escape room that they create using CoSpaces, a block-based programming language.

SPARCS brings participants together for a week-long stay at the University of Waterloo, though this year it will be held online. Participants learn how to code, get hands-on experience building circuits, are introduced to theory and develop new friendships with like-minded peers.

NURTURING CURIOSITY

Part of SPARCS and much of the CEMC's resources and programming draw attention to the connection between computer science and the real world. Recognizing that computer science plays a significant role in many areas of life that interest students — from app development to technology creation, finance, medicine and more — is key.

“When I was a kid growing up, computer science was over there, in its little box, and the rest of the world was over here,” explains Sarah Chan, senior resource design specialist at the CEMC.

“Now, the box has opened. Computer science is everywhere. You can't say, ‘that's over there and it doesn't concern me.’ That's why it's important for students to be interested in the social implications of computing. How does this affect your life? It's impacting you, you're using it, so you should have a say in it.”

The desire to inspire curiosity about the why — and sometimes the why not — of computer science and technology has led Chan to create a new resource for teachers: Computer Science and Society. The computer science curriculum in schools includes topics like ethics, environmental waste, smartphone addiction and emerging technologies, and yet Chan and others realized that teaching these topics was proving to be a challenge for many time-strapped teachers. A series of ready-made lessons that teachers can use in their classrooms, Computer Science and Society is the CEMC's answer to the growing demand for computer science education that engages in the social implications of computing.

LOOKING AHEAD

With a holistic approach to computer science outreach education, the CEMC is working to equip students with needed skills and capacities, make space for kids and young people to see futures in computing and nurture their curiosity about the role computer science plays in shaping our world.

We invite you to explore our computing resources and events at cemc.uwaterloo.ca.

CEMC TO CREATE NEW RESOURCES FOR ELEMENTARY SCHOOL STUDENTS

CEMC TO INTRODUCE NEW ONLINE COURSEWARE WHICH WILL HELP STUDENTS THRIVE IN MATH AFTER THE DISRUPTION OF THE PANDEMIC

BY ROBIN MORDEN

If you were to visit a Canadian elementary school math classroom, you'd likely see a committed teacher and students working diligently on their math lesson. Your impression would be of a classroom that clearly values and promotes learning.

And this impression wouldn't be wrong. However, what you wouldn't see—and what you might be surprised to discover—is that many of these math students are actually struggling and the teacher is feeling overwhelmed.

“Often, the students are working across four or five different grade levels,” explains CEMC Director Ian VanderBurgh. “And while the teacher wants to improve their students' learning, they simply cannot assemble the resources and supports in the time given them. Due to no fault of their own, they cannot easily differentiate their instruction to give all their students the individualized learning assistance that they need.”



Worse, the COVID-19 pandemic has only exacerbated these challenges. Throughout the pandemic, teachers and students were forced to manage through a demanding mix of in-person and online learning. Faced with these new challenges, it became even more difficult to individualize the learning. School shutdowns have affected 90 per cent of the world's student population and, according to the Organisation for Economic Co-operation and Development, are the "greatest disruption in educational opportunity worldwide in a generation."

"Before the pandemic, we had significant concerns across Canada about the state of elementary mathematics education," says VanderBurgh. "Were our children being prepared enough for the 21st-century world? Were they keeping up globally? These concerns were in no way a reflection on our exceptional and dedicated teachers but instead related to larger, systemic challenges. Now, as we look to emerge from the pandemic, we worry about how we can address the vast disparities in our students' backgrounds and abilities caused by COVID-19."

CEMC TO INTRODUCE NEW COURSEWARE TO HELP CLOSE THE GAP

These challenges in math education are the impetus behind the CEMC's plan to create new elementary courseware. The free online courseware will cover the content taught in Grades 4/5/6 in ways that are accessible and appropriate

for these younger audiences and their teachers, and in ways that first and foremost promote the thinking that lies at the heart of mathematics. The aim is to supplement classroom learning with feature lessons, interactive activities, enrichment challenges, and unlimited opportunities for practice, in order to boost the confidence and ability of our students in math.

It's a new project, but it is built on a proven concept. CEMC already offers similar courseware for students in Grades 7 to 12, and it has proven wildly successful, particularly during the pandemic when demand for the materials skyrocketed.

Rich Dlin, a Toronto teacher, recalls the chaos of the transition to virtual education in March of 2020 and the help that CEMC's courseware provided.

"Teachers had very little time to prepare lessons in an online format," says Dlin. "Stress and anxiety levels went off the chart—except in the mathematics department. We used the CEMC courseware heavily. The students appreciated the platform and the thoughtfulness of the lessons."

Dlin and his colleagues were not alone in their use of the CEMC courseware as a go-to resource. The comprehensive courseware for Grades 7 to 12 received over 23 million pageviews and more than 800,000 hours were spent on the courseware website in the last two years. The CEMC has received feedback from countless educators, parents, and children around the world that this entirely free, online resource was invaluable to their students.



“MY OWN JOURNEY WITH MATH AND COMPUTER SCIENCE STARTED EARLY, AND I WAS VERY FORTUNATE TO HAVE VERY SUPPORTIVE TEACHERS AND PARENTS THAT FOSTERED MY EXCITEMENT AND INTEREST. I SEE THE CEMC PROGRAM AS AN OPPORTUNITY TO SPARK THIS SAME EXCITEMENT IN MORE STUDENTS, REACHING THEM EARLY, AND AVOIDING THE AFOREMENTIONED PERCEPTION AND MOTIVATION CHALLENGE BY SIMPLY CLOSING THE DOOR ON IT.”

– JEROMY CARRIERE (BMATH '95)
SENIOR VICE PRESIDENT OF ENGINEERING AT DATADOG

NEW COURSEWARE TO BE MADE POSSIBLE BY WATERLOO ALUMNI AND DONORS

Jeromy Carriere (BMath '95), Senior Vice President of Engineering at Datadog and Waterloo computer science alumnus, made a generous gift in early 2022 to help launch the elementary school project. His own experience helping his daughters (one is about to graduate from Queen's University, and the other finishing middle school in New York City and starting high school in the Fall) learn mathematics inspired him to give. He saw firsthand some of the difficulties unique to math education, including the self-defeating preconceptions that many children bring to the subject.

“There remains a significant perception that math is inherently ‘hard,’ and this represents a big challenge to students in terms of motivation,” says Carriere. “And without motivation, in my experience, ongoing enjoyment and success are much harder to reach.”

To change the way kids think about math, Carriere believes that it's important to reach them when they are young.

“My own journey with math and computer science started early, and I was very fortunate to have very supportive teachers and parents that fostered my excitement and interest,” says Carriere. “I see the CEMC program as an opportunity to spark this same excitement in more students, reaching them early, and avoiding the aforementioned perception and motivation challenge by simply closing the door on it.”

Paul and Cathy Cotton, alumni and longtime philanthropic supporters of the Faculty, also made a gift in support of the project. Like Jeromy, they believe providing children with an early start in math is critical.

“We were fortunate to have an early introduction to mathematics and we want future generations of Canadian students (and students worldwide) to benefit from what we experienced,” says Paul Cotton. “Our parents and teachers encouraged our early interests in mathematics and we want to support CEMC to deliver this kind of mentoring to younger students and their teachers through this new courseware.”

They believe math education has never been more relevant or more important, particularly in a world increasingly dominated by data.

“We want to help CEMC to encourage young Canadians to use computational thinking skills to understand everyday issues like climate change, pandemic risks, etc.,” says Paul. “As many jobs become more data-centric, we need to build an educational system that produces students who are data-aware. This new courseware for younger students (and their teachers) will help Canadians handle the mathematics they need in their everyday lives and may inspire students to pursue careers in the emerging data-centric economy.”

While generous donors are helping the CEMC to launch the program, it is not yet fully funded. If you are interested in bringing engaging and effective mathematical learning material to our elementary school students, please contact Alex Lippert, Associate Director of Development, at alex.lippert@uwaterloo.ca.



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