Mathematics Outreach for Motivating Students to Prepare for STEM Careers

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The STEM fields (encompassing natural sciences, mathematics and statistics; information and communication technologies; and engineering, manufacturing and construction) are especially important for fostering innovation and economic growth. Almost all top ten best jobs of 2017, published by CareerCast.com, are STEM-related jobs. Four of the jobs are explicitly mathematical, and seven involve mathematics and computing. On the other hand, results of the Education at a Glance 2017 study show that STEM is a less attractive field of study in which post-secondary students enrol, even though graduates from STEM disciplines are usually the most employable, and particularly so graduates in information and communication technologies (ICT). The field of ICT attracts less than 5% of new entrants, the smallest share to a field of study, yet yields the highest employment rate on average across OECD countries, signalling a shortage of supply.[1] Workers who successfully combine mathematical and interpersonal skills in the knowledge-based economies of the future will be, and already are, highly prized.

How can IEEE volunteers, including industry professionals and university educators, motivate the new generation to want and prepare for one of these great jobs? What skills should individuals be acquiring to ensure they have value in the modern workplace? To be successful in STEM education, one must be ready for challenging work, and develop the qualities of perseverance and focus. Preparing for careers in STEM must start early – teachers and parents should be a part of the process. Some may be surprised to learn that skills children develop in pre-school such as sharing and negotiating will be crucial and valued highly. "Along with those soft skills, mathematical ability will be enormously beneficial," according to weforum.org.[2]

The Teacher In-Service Program (TISP) connects IEEE volunteers with pre-university educators and students. TISP volunteers share their real-world experiences, and demonstrate engineering, science and mathematics concepts. The Canadian Math Kangaroo Contest (CMKC) is a volunteer-run, not-for-profit organization, with similar goals – to spread the joy of mathematics, science and engineering and instil a passion for these subjects among youth in an inclusive atmosphere.

Competing in math can start from grade 1

Participating in math contest-games can start in grade 1. Math and science competitions are often neglected in Canada as a motivating tool for awakening and developing the curiosity and interest of students. Some of these young children might become future inventors. No one expects that the participants in math competitions will all become mathematicians, just as not all children who take sports or music lessons become athletes or musicians. Parents are seeking challenging math programs for their children in order to develop children' analytical and problem-solving skills. The impression exists that schools nowadays fail to sufficiently develop in children a love and appreciation of mathematics. Certainly, university educators are concerned about the fact that students arrive with certain attitudes toward mathematics, which is an obstacle in getting them excited about all other science and engineering areas. The STEM university teachers and students can help.

The Great Canadian Math Debate

The K-12 mathematics curricula in many provinces of Canada are sources of confusion for teachers, students, and university educators. Children in elementary school are asked to discover and devise their own personal strategies prior to being taught standard arithmetic facts. As a result, many students do not understand and master mathematics; naturally, standardized math scores have been declining. Understanding and skills are essential for doing well in mathematics. Acquiring and retaining math skills requires memorization and practice, effective not only in math but in all natural sciences. How can one progress in engineering, medicine, modern technologies, if every generation has to "discover" every phenomenon already documented? There is hope for improvement after some changes in math curricula took place during the past years. A positive action indeed but a lot more is needed for fixing the broken curricula.

Canadian Math Kangaroo

The purpose of the game contest is to stimulate and motivate the largest possible number of students (as a complement to other activities, competitions, Olympiads and rallies). Consequently, the overarching goal of the CMKC program is to inspire and support students in Canada to choose careers in math, science and technology-related fields, and to help them succeed in their studies. Indirectly, this is achieved by raising awareness and appreciation of math challenges among broader communities, as well as by supporting and educating teachers in providing challenging math opportunities in their classrooms.

It is worth mentioning, as well, that there are unique benefits of Math Kangaroo for mathematically promising students of all ages. Such students are usually under-served in the public education system, which does not provide them with enough challenging and motivating tasks.

The CMKC is part of a broader international project that, as of 2017, involves over six million students and hundreds of mathematicians from more than 65 countries. The contest is organized by the international association "Kangourou Sans Frontières" as an annual game-contest, usually held in March. It consists of a multiple-choice game-test, that is open to all students in grades 1-12, and is an inclusive and broad participation contest-game.

The best part of the competition are the problems – they are provocative, require a great deal of attention and creative thinking, and cover inter-

[1] OECD (2017), Education at a Glance 2017: OECD Indicators, OECD Publishing, Paris. http://dx.doi.org/10.1787/eag-2017-en

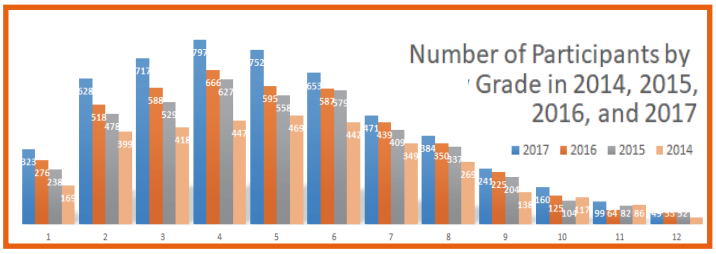
[2] https://www.weforum.org/agenda/2016/09/jobs-of-future-and-skills-you-need/, World Economic Forum

esting mathematical concepts. Students, teachers, and parents love the problems. They are selected from a larger set of problems proposed by the participating countries each year. Representatives from all countries make the selection during the annual meeting of the international association. Finally, countries are authorized, for reasons justified by the characteristics of their school curricula, to make specific changes in the sets.

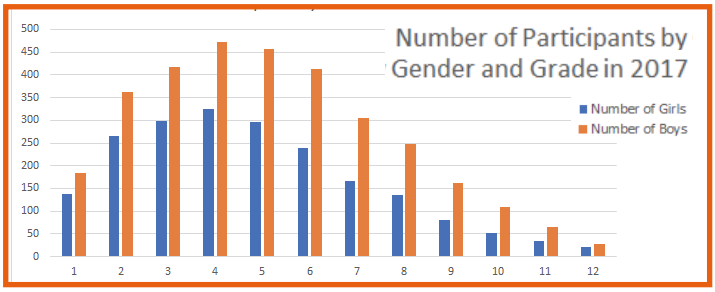
The following sample problem [2014, grade 5-6 paper] was solved correctly by only 11% of the students in grade 5 and 17% of those in grade 6: "It takes Ben 30 minutes to cut a long log of wood into six pieces. How long does it take him to cut another log of wood into nine pieces? (A) 40 (B) 44 (C) 45 (D) 48 (E) 54."

The CMKC contest was offered by 48 institutions in 2017, with a total number of participants 5274. ▼

The number of participants per grade also increased in 2017. ▼



The number of boys outnumbered the number girls. ▼



There is potential for attracting even more participants in many regions. CMKC is constantly seeking ways to expand the contest and its programs, aiming to reach more participants and volunteers across the country. CMKC will work with other organizations to attract more girls to participate in the CMKC programs.

Training activities

- **Math clubs (also known as math circles) and training sessions:** Math clubs aim to challenge and stimulate students with advanced and entertaining mathematical topics, and to prepare students for national and international competitions such as the Canadian Math Kangaroo Contest. A core purpose of the clubs is to meet the educational needs of students who require math challenges beyond the regular school curriculum. Students who learn advanced math have better grades in school, and become better prepared for more rigorous math in high schools and universities. The clubs provide fun, friendly and welcoming places for students to interact with peers who are also interested in math. This is often difficult to achieve in a conventional classroom as there are different interests and abilities. The math clubs offer students ample opportunities to learn from each other and support each other in their math journey.

- **International competitions and training**: Students have participated in international mathematics competitions in Asia and Europe. The training classes prepared students for these contests, and the improved scores boosted their interest and motivated them to work harder. Representing Alberta and Canada in international contests is also an experience that students treasure for a lifetime.

Workshops and math and science fairs

- **TISP workshops to K-12 teachers and students:** Promotion of math and science-related activities for the public are facilitated by the IEEE and CMKC through special sessions bringing together interactive, hands-on science and engineering experiences. An example would be the IEEE TISP activities held with the purpose of showing how mathematics, science, and engineering are related.

- **Coding workshops bringing computer science to local school or district:** IEEE TISP and Math Kangaroo Edmonton hosted two Hour of Code workshops for students, teachers, and parents in November 2016. The workshops were attended by approximately 160 people. Hour of Code https://code.org/ and EU Code Week http://codeweek.eu/ websites contain great resources.

- **Math and science fairs:** The Math Fairs are non-competitive events where students can solve a variety of math and logic puzzles at their own pace. Hosting a Math Fair during math club sessions helps students do problem solving with a goal in mind. IEEE Northern Canada Section also supports Edmonton Regional Science Fair providing opportunities for students to build a life-long love of scientific discovery and learning.

Besides an improvement in grades and contest scores, students who receive training also develop mathematical and critical thinking, which in turn fosters problem-solving skills, creativity, confidence, attention to details and leadership skills. Team training in the program promotes teamwork and collaboration which are invaluable in the workplace. These skills will help students become more productive citizens and employees, thus contributing to our country's future and economy.

What is most rewarding in this work?

Seeing the sparks in children' eyes during challenging outreach experience. It is great to share love and passion with others who can change the future in positive ways. People are usually interested in helping because they love to teach, they are passionate about math, it is for a worthy cause, and they are satisfied to see improvement.

Here are some testimonials on what motivated individuals to volunteer for Math Kangaroo contest and clubs:

> **"I really like what these clubs are doing for students [who are] curious about math outside of what they see in school"**
> — a PhD pure mathematics student.

> **"It might change the life of some of the kids"**
> — one enthusiastic volunteer.

For more information, please have a look at: **www.mathkangaroocanada.com**. Those interested in administering the Canadian Math Kangaroo contest in a school or university can find an application form from the Contact page of the website. ■

About the Author

Rossitza Marinova (SMIEEE) has been a Professor in Mathematics and Computing Science at Concordia University of Edmonton since 2004. She has a Ph.D. in Computational and Applied Mathematics (Bulgarian Academy of Sciences), M.Sc. in Mathematical Modeling, and B.Sc. in Mathematics (Sofia University, Bulgaria). She also worked as a research scientist in the software development industry in Canada and in the National Aerospace Laboratory of Japan. Dr. Marinova is a member of the IEEE TISP Canada committee, contributing through her long-standing service as co-secretary, co-organizing numerous Edmonton-area events and playing a role in several national TISP Canada workshops. She is 2018 Chair of IEEE Canada's Educational Activities Committee. Dr. Marinova is a Life Member of Canadian Mathematical Society and a member of Canadian Applied and Industrial Mathematics Society.