The Variable

Presented by the Saskatchewan Mathematics Teachers' Society

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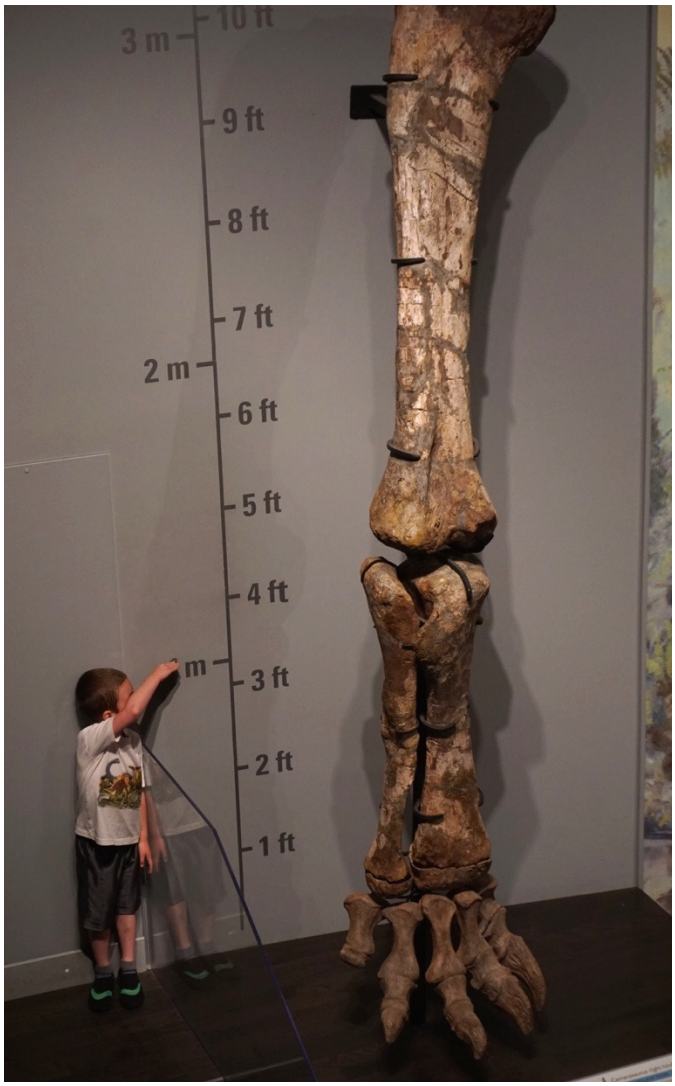

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Cover art

"This photo was taken at the Royal Tyrrell Museum in Drumheller, Alberta.

How many boys tall is the dinosaur leg? How many teachers tall? What else do you notice and wonder?"

Ilona Vashchyshyn

SMTS Executive (2016-2018)

The Variable

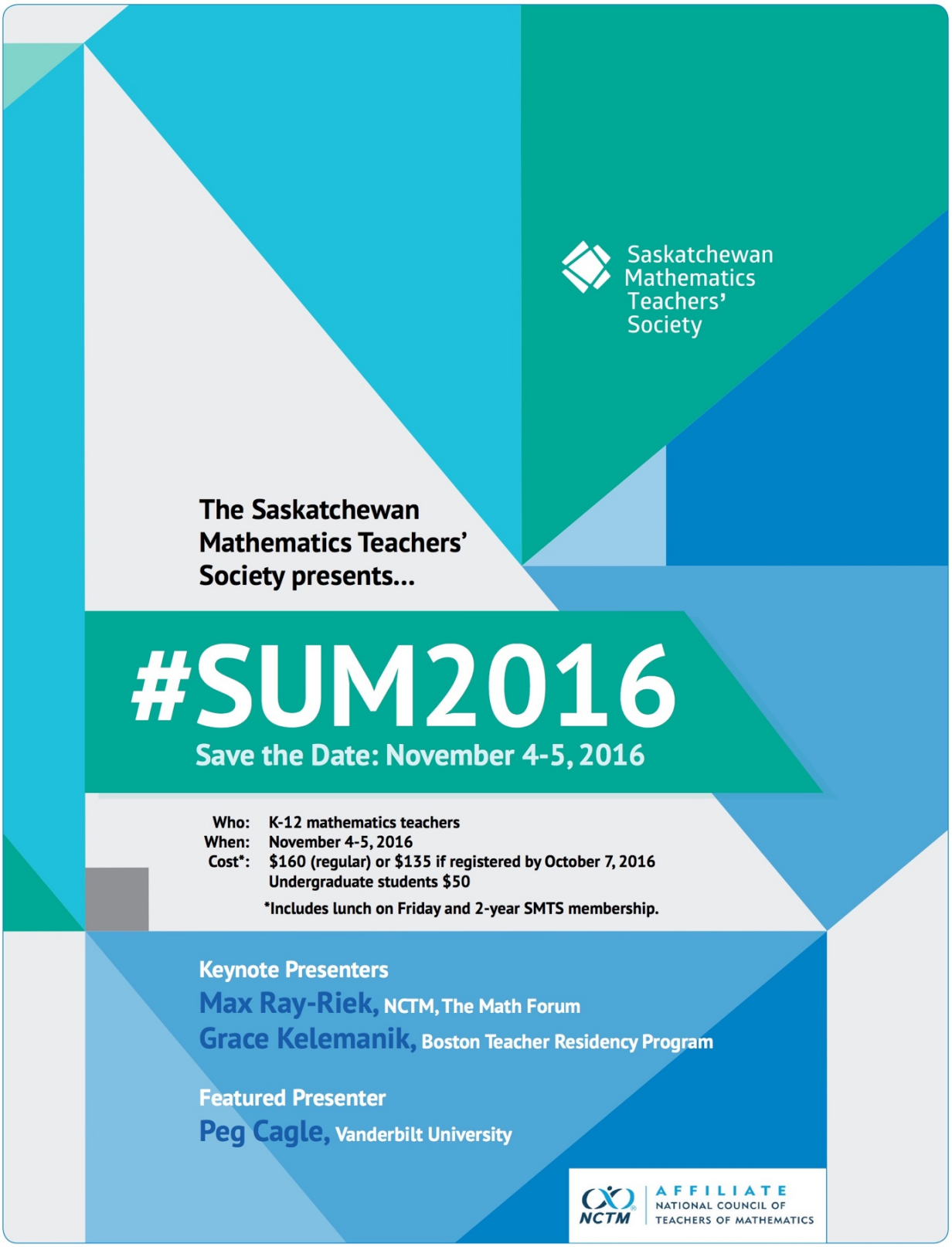
Notice to Readers

The views expressed in *The Variable* are those of the author(s), and not necessarily those of the Saskatchewan Mathematics Teachers' Society. In the publishing of any works herein, the editorial board has sought confirmation from all authors that personal quotes and examples have been included with the permission of those to whom they are attributable.

Notice to Contributors

The Variable welcomes a variety of submissions for consideration from all members of the mathematics education community in Canada and beyond, including classroom teachers, consultants, teacher educators, researchers, and students of all ages, although we encourage Saskatchewan teachers of mathematics as our main contributors. Submitted material is assessed for interest, presentation, and suitability for the target audience.

Please submit articles by email to thevariable@smts.ca in Microsoft Word format. Articles should be limited to 3000 words or less; authors should also include a photo and a short biographical statement of 75 words or less. Accepted contributions are subject to revision. Editors reserve the right to edit manuscripts for clarity, brevity, grammar, and style.


Saskatchewan Mathematics Teachers' Society
The Saskatchewan Mathematics Teachers' Society presents...
#SUM2016
Save the Date: November 4-5, 2016
Who: K-12 mathematics teachers
When: November 4-5, 2016
Cost*: $160 (regular) or $135 if registered by October 7, 2016
Undergraduate students $50
*Includes lunch on Friday and 2-year SMTS membership.
Keynote Presenters
Max Ray-Riek, NCTM, The Math Forum
Grace Kelemanik, Boston Teacher Residency Program
Featured Presenter
Peg Cagle, Vanderbilt University
NCTM
AFFILIATE
NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

Message from the President

Welcome to the October edition of The Variable! Now that we're all in the thick of it, congratulations! You're amazing! We're a bit away from a real break yet, however, and there are still some big milestones yet to hit. As educators, we tend to focus our thoughts on what *more* we could be doing for our students or colleagues. Our never-ending desire to support our students and to push our own learning forward leads us to doing more and more, and this doesn't even begin to factor in our personal lives.

So, as we head into a weekend of learning together at the Saskatchewan Understands Math conference, I invite you all to reflect on a minimum of one thing that you could strategically *stop* doing. What is one thing you're currently doing in your teaching practice or school-related life that isn't bringing you the kind of value it should be for the effort it involves? What might you let go of, to make room for both new learning and self-care?

Are there responsibilities that your students can start to take over? Now that your classroom routines and procedures are well underway, perhaps your students might start to take on more of the maintenance of your classroom space. Or maybe they might start to take on larger roles in their assessment processes. While they might need some initial support, students can track feedback in various forms and provide feedback to their peers, lightening your role and providing them with rich learning opportunities.

Are you trying to mark every single assignment, when you might introduce a rotation system in which a few students receive detailed feedback at a time? Are you trying to pack in too many small things into a lesson and having to rush through important pieces of learning? Is there an app that could help you manage your workflow and eliminate some paperwork? Or conversely, is trying to implement a specific piece of technology proving to be more effort than payoff?

If nothing else, I hope the exercise of considering what you might stop doing proves to be a valuable one, even if the result is only a plan for not doing something next year. Thinking about what we might stop doing, in service of student learning and our overall teaching practice, deserves a bit of time in the spotlight. It may also make for great lunchtime conversation this week at SUM conference, even if you're only joining us virtually. 'Til next month, happy learning!

Michelle Naidu

Problems to Ponder

Welcome to the October edition of Problems to Ponder! This month's problems have been curated by Michael Pruner, president of the British Columbia Association of Mathematics Teachers (BCAMT). The tasks are released on a weekly basis through the BCAMT listserv, and are also shared via Twitter (@BCAMT) and on the BCAMT website.

Have an interesting solution? Send it to thevariable@smts.ca for publication in a future issue of The Variable.

British Columbia Association of Mathematics Teachers

I am calling these problems 'competency tasks' because they seem to fit quite nicely with the curricular competencies in the British Columbia revised curriculum. They are non-content based, so that all students should be able to get started and investigate by drawing pictures, making guesses, or asking questions. When possible, extensions will be provided so that you can keep your students in flow during the activity. Although they may not fit under a specific topic for your course, the richness of the mathematics comes out when students explain their thinking or show creativity in their solution strategies.

Because I am currently using these tasks with my own classes (Grades 8-12) and it is the start of the year, I am sharing tasks that are my favorites for building a problem solving and collaborating culture with students; as such, some of these tasks may already be familiar to many of you.

I think it would be fun and more valuable for everyone if we shared our experiences with the tasks. Take pictures of students' work and share how the tasks worked with your class through the BCAMT listserv [*which currently connects nearly one thousand educators from across the province, country, and even the world! –Ed.*] so that others may learn from your experiences.

I hope you and your class have fun with these tasks.

Michael Pruner

Intermediate and Secondary Tasks (Grades 4-12)

September 5, 2016

The Tax Collector
Start with a collection of paychecks from $1 to $12. You can choose any paycheck to keep. Once you choose, the tax collector gets all paychecks remaining that are factors of the number you chose. The tax collector must receive payment after every move. If you have no moves that give the tax collector a paycheck, then the game is over and the tax collector gets all the remaining paychecks. The goal is to beat the tax collector.

Example
Turn 1: Take $8. The tax collector gets $1, $2 and $4.
Turn 2: Take $12. The tax collector gets $3 and $6 (the other factors have already been taken).

Turn 3: Take $10. The tax collector gets $5.
You have no more legal moves, so the game is over, and the tax collector gets $7, $9 and $11, the remaining paychecks.

Total scores:
You: $8 + $12 + $10 = $30.
Tax Collector: $1 + $2 + $3 + $4 + $5 + $6 + $7 + $9 + $11 = $48.

Extensions: What is the highest score you can achieve? What is the lowest score? What if you had 18 paychecks?

Source: Antonick, G. (2015, April 13). The tax collector. *The New York Times*. Retrieved from http://wordplay.blogs.nytimes.com/2015/04/13/finkel-4/?_r=0

September 11, 2016

The Game of 31
Players take turns picking any number from 1 through to 6. Each time a number is picked, it is added to the total score. The player who makes the total score add to 31 wins.

Extensions: What if 31 loses? What if you can choose from 2 through 6?

Replacing Coins
On a table, there are 1001 loonies lined up in a row. I come along and replace every second coin with a nickel. After this, I replace every third coin with a dime. Finally, I replace every fourth coin with a quarter. After all this, how much money is on the table?

Extensions: Why is the repeating pattern 12? Design a task that has a repeating pattern of 15. How many starting loonies are needed to make a total of $100?

September 18, 2016

Filling Jugs
You have a 3 L jug and a 5 L jug and an unlimited supply of water. How can you measure exactly 4 L of water?

Extensions: What if not 4 L? What if not 3 L and 5 L? What if the jugs were 3 L and 6 L? or 3 L and 7 L?

Flip a Card, Toss a Card
Start with the cards ace, two, three, four, and five. Arrange the cards in such a way that they come out in increasing sequence when you deal the cards out like this:

1. top card – place on table
2. next card – place at bottom of deck
3. repeat this process until all cards are on the table.

What is the pattern? What is your strategy?

Extensions: Add more cards to the deck. Can you do 13 cards? 52 cards? 104 cards?

Source: Liljedahl, P. (2015, March 18). *15243* [Video file]. Retrieved from https://youtu.be/FOcqqV0IdQ8

September 25, 2016

Using 4's
Write each number from 1 – 10 using exactly 4 fours and any mathematical sign or symbol.

Extensions: 1 – 20 or 1 – 100. Can you do this with 4 fives, or 4 threes, etc…?

The Frog Puzzle
Three green frogs are trying to change position with 3 orange frogs. Green frogs and orange frogs can only move forward onto an empty lily pad or leap frog over a single frog onto an empty lily pad.

How many moves are required to solve this puzzle?

Extensions: What if there were 4 frogs on each side (or 5 frogs, or *n* frogs…)? What if the number of frogs on each side is not equal? How can you communicate the solution to a friend over the phone?

Source: The frog puzzle. (n.d.). Retrieved from https://britton.disted.camosun.bc.ca/frog_puzzle.htm

Primary Tasks (Grades K-3)

September 25, 2016

How Many Are Hiding?

Materials:
- 10 or more snap cubes / objects per player
- a cup for each player

In this activity, each child has the same number of cubes and a cup. They take turns hiding some of their cubes in the cup and showing the leftovers. Other children work out the answer to the question "How many are hiding," and say the full number combination.

Example: I have 10 cubes and I decide to hide 4 in my cup. My group can see that I only have 6 cubes. Students should be able to say that I'm hiding 4 cubes and that 6 and 4 make 10.

Source: How many are hiding? (n.d.). Retrieved from https://www.youcubed.org/task/how-many-are-hiding/

Michael Pruner is the current president of the British Columbia Association of Mathematics Teachers (BCAMT) and a full-time mathematics teacher at Windsor Secondary School in North Vancouver. He teaches using the Thinking Classroom model where students work collaboratively on tasks to develop both their mathematical competencies and their understanding of the course content.

SUM Conference 2016

It's almost here!

Join us on **November 4-5th** at the Circle Drive Alliance Church in Saskatoon for this year's Saskatchewan Understands Mathematics (SUM) Conference, two days packed with professional learning opportunities for educators teaching in Grades K-12. Registration includes lunch on Friday and a 2-year SMTS membership.

Curious about this year's keynote speakers?

Grace Kelemanik

Grace Kelemanik (@GraceKelemanik) works as a mathematics consultant to districts and schools grappling with issues related to quality implementation of the Common Core State Standards. She is particularly concerned with engaging special populations, including English Language Learners and students with learning disabilities, in the mathematical thinking and reasoning embodied in the eight Common Core standards for mathematical practice. Kelemanik is a secondary mathematics Clinical Teacher Educator for the Boston Teacher Residency Program, a four-year teacher education program based in the Boston Public School district that combines a year-long teacher residency in a school with three years of aligned new teacher support. Prior to BTR, Grace was a project director at Education Development Center (EDC). She was lead teacher of mathematics at City on a Hill Public Charter School in Boston where she also served as a mentor to teaching fellows and ran a support program for new teachers. Grace is co-author of the book, *Routines for Reasoning*, about instructional routines that develop mathematical practices.

Learn more about Grace Kelemanik's work and her upcoming SUM session in the August edition of Spotlight on the Profession (*The Variable* Volume 1, Issue 5).

Max Ray-Riek

Max Ray-Riek (@maxmathforum) works at The Math Forum, NCTM, and is the author of the book *Powerful Problem Solving*. Max is a former secondary mathematics teacher who has presented at regional and national conferences on fostering problem solving and communication and valuing student thinking.

Learn more about Max Ray-Riek's work and his upcoming SUM session in this month's Spotlight on the Profession column; see page **Error! Bookmark not defined.**.

Website: http://mathforum.org/blogs/max/

For more information about SUM and to register, visit our website at http://smts.ca/sum-conference/. We hope to see you there!

Reflections

Reflections *is a monthly column for teachers, by teachers on topics of interest to mathematics educators: reflections on classroom experiences, professional development opportunities, resource reviews, and more. If you are interested in sharing your own ideas with mathematics educators in the province (and beyond), consider contributing to this column! Contact us at thevariable@smts.ca..*

That's SUM Conference, Alright!

Sharon Harvey

I I am currently serving my first year as treasurer of the Saskatchewan Math Teachers' Society (SMTS). Over the past year, I have learned so much about what the SMTS is and what the SMTS does. I have also learned that some of you—our members and readers—have some misconceptions about the SMTS.

We started *The Variable* as one of the ways to address this. We wanted to make sure that you knew how to contact us, what we were working on, and to keep the lines of communication open with Saskatchewan teachers and learners of mathematics. And so, for this month's edition of *Reflections*, I decided that I would take the time to address some of these misconceptions (myths) head-on. Hopefully, this will help to complete your picture of the SMTS, as it did mine!

Myth: SMTS is STF

Truth: The SMTS is a Professional Growth Network (PGN) that operates under the Saskatchewan Teachers' Federation (STF). What's a PGN? According the STF Professional Growth Networks administration manual (p. *i*),

> [Professional growth] networks support professional growth and lifelong learning of teachers through networking, communications, innovative professional growth opportunities and sharing of promising practices and resources related to specialized are of practice or interest in education.

While we do get some funding and lots of support from the STF, we are not *the* STF.

Myth: SMTS is for post-secondary students or early-career teachers only

Truth: SMTS does serve post-secondary students and early-career teachers, but not exclusively: We aim to support *all* teachers and *all* learners of mathematics. Our door is open to anyone who wants to learn mathematics, teach mathematics, or share their experiences with mathematics teaching and learning! More specifically, we plan the annual Saskatchewan Understands Mathematics

"Our door is open to anyone who wants to learn mathematics, teach mathematics, or share their experiences with mathematics teaching and learning."

(SUM) conference and publish our monthly periodical, *The Variable*, with teachers of all grades and experience levels in mind.

Myth: SMTS is not affiliated with NCTM

Truth: The SMTS *is* an NCTM Affiliate.

In case you aren't familiar with the National Council of Teachers of Mathematics (NCTM), which is based in the United States, it is the largest mathematics education organization in the world. The NCTM supports teachers and learners of mathematics in many ways, with 80,000 members and more than 230 Affiliates throughout the United States and Canada. The NCTM offers many services, from hosting conferences and workshops large and small, to offering scholarships, answering your questions at Dr. Math, and much more!

NCTM Affiliates—which include the SMTS—are independent organizations that have goals that align with the mission of the NCTM. If you are registering for an NCTM membership, be sure to support the SMTS by noting your affiliation during registration.

Myth: SMTS serves teachers only

Truth: Our vision is to support both the teaching and learning of mathematics in Saskatchewan. As such, we offer two major events throughout the year: the Saskatchewan Understands Math (SUM) Conference and Saskatchewan Math Challenge (SMC). SUM conference is an event for K-12 mathematics educators who are interested in curriculum, instruction, assessment, number sense, technology, and more. For (school-age) learners of mathematics, the SMTS has hosted the Saskatchewan Math Challenge. The day included activities and challenges that allowed students to engage with each other and with mathematics in new, exciting ways.

Myth: SMTS is SUM

Truth: SUM is a conference that is hosted by the SMTS. It stands for Saskatchewan Understands Mathematics. The SMTS executive plan, organize, and host the conference to give our members the opportunity to network, share, and learn together.

Myth: SUM is for [*insert teaching level*] teachers/specialists only

Truth: SUM is for anyone who has an interest in learning more about the teaching and learning of mathematics. We welcome teachers, post-secondary students, consultants, and leadership to our conference. This two-day event is packed with amazing keynotes, fabulous session presenters, and vendors.

There are sessions relevant to teachers of all levels, from K-12. This year, for instance, at SUM 2016, you can learn to code with your elementary students, or facilitate great group work with your middle years, or investigate responsiveness in your secondary class, or learn about a group of leaders in FNIM work, and much more. There is something for everyone.

To summarize, the SMTS is a vibrant group of teachers who want to help you achieve your goals in math education. I hope that unpacking these myths has allowed you to learn more about what we do for Saskatchewan teachers and learners of mathematics. If you have still have any questions, however, please don't hesitate to contact us. But next time you hear one of these myths, you can help us out: remind them that the SMTS is a PGN under the STF, an affiliate of NCTM, and hosts SMC and SUM. That'll clear them right up!

References

Saskatchewan Teachers' Federation. (2016). *Professional Growth Networks administration manual 2016-17.*

Sharon Harvey has been a teacher within the Saskatoon Public School Division for eight years. She has taught all secondary levels of mathematics, as well as within the resource program. She strives to create an inclusive and safe environment for her students.

Do you know a teacher who uses innovative teaching strategies to excite and inspire their students in math class? An individual or group who has had a tremendous impact on mathematics education in Saskatchewan?

Nominate them for a Saskatchewan Mathematics Teachers' Society Award!

See page 45 for details.

Spotlight on the Profession

In conversation with Dr. Harley Weston

In this monthly column, we speak with a notable member of the mathematics education community about their work and their perspectives on the teaching and learning of mathematics. This month, we had the pleasure of speaking with Dr. Harley Weston.

Harley was born and raised in Southern Ontario and went to high school in Caledonia, where a Grade 10 teacher taught him geometry using Euclid as the text. This is where he was first introduced to the beauty and lure of mathematics. He received an undergraduate degree from McMaster University and a Masters and PhD from Lehigh University in Bethlehem, Pennsylvania. In 1967, Harley and his wife Marianne moved to Regina, where they lived for almost 50 years. He taught in the Department of Mathematics and Statistics until his retirement in 2005. His research was in Point Set Topology for a few years, after which his interests turned to Applied Mathematics and Mathematical Modelling. Starting in about 1995, his academic interests changed again, this time to Mathematics Education. In 1992, he was awarded the University of Regina Alumni Association Award for Excellence in Undergraduate teaching, in 2007 the annual Education Prize from the Pacific Institute for the Mathematical Sciences, and in 2008 the Adrien Pouliot Award from the Canadian Mathematical Society.

Harley and Marianne have two sons, three granddaughters, and two great granddaughters. They now live in the hamlet of Pasqua Lake in the Qu'Appelle Valley.

Thank you for taking the time to have this conversation, Dr. Weston. I would like to start by asking you about your interest in mathematics education. Your background is in applied mathematics, and this was the focus of your research at the Department of Mathematics and Statistics at the University of Regina from 1967 until 2005. However, you have also spent much time cultivating relationships between mathematicians, K-12 students, mathematics teachers, and Education faculty. In your view, why is it important to establish dialogue between these groups?

Thank you for inviting me to be part of this endeavour.

> "I have always been passionate about the beauty and elegance of mathematics and have used my teaching as an attempt to help others glimpse the beauty that I see."

When I arrived in Regina in 1967, my academic interest was in pure mathematics, and it wasn't until about 1980 that I became interested in applied mathematics. I have always been passionate about the beauty and elegance of mathematics and have used my teaching as an attempt to transmit my love of mathematics and to help others glimpse the beauty that I see. At times, however, I have been frustrated by the fact that many people don't share this view of mathematics or even appreciate how anyone could have this view. I think that part of the reason that so many people have a negative view of mathematics is due to the way that it is taught, and I felt that I had much to learn about mathematics teaching from

my colleagues in mathematics education. Fortunately, at the University of Regina there was already a close working relationship between some of my colleagues in the Department of Mathematics and Statistics and faculty in the Faculty of Education, so it was relatively easy for me to build on this.

In my view, those of us who are faculty members in mathematics can learn from a relationship with education faculty, teachers, and K-12 students. Many of the students we teach are students in the Faculty of Education, and it is valuable to know what their faculty expects of them. It is also very valuable to know what we can expect from students as they transition from high school to university. Furthermore, mathematics faculty have much to offer to faculty members in education and the K-12 community, both in their knowledge of the subject area and their passion for it.

In what ways do you suggest that mathematicians reach out to members of the mathematics education community (including students, teachers, and Education faculty), and how did you do so personally? In what ways can the relationships be reciprocal, or mutually beneficial?

In my experience, nothing is as valuable as finding a project to work on with a colleague in education. Before I became involved, members of our department and members of the faculty of education worked together to design a mathematics course that is a requirement for all education students in the elementary program. This course is taught by members of both units, which helps maintain the contact. We also worked together on an annual math camp where we involved mathematics and mathematics education students as volunteers. These students take classes together, but may have little contact otherwise. It is valuable for them to work together, and in particular in our math camp, the mathematics students see that the mathematics education students have skills and knowledge that may not be evident in mathematics classes.

> "I have found that if you give students as much freedom as possible, they excel in the work."

In addition, I work with mathematics education faculty and students on Math Central, Aboriginal Perspectives and Math on the Move. Over the years, I have hired many mathematics education students in these projects and have found it very rewarding; I think that the students found it rewarding as well. I have found that if you give the students as much freedom as possible, they grow professionally and excel in the work.

One of your own ongoing outreach efforts is Math Central (http://mathcentral.uregina.ca), a collection of internet services designed for teachers and students of mathematics at the K-12 level. Created in 1995 and maintained by University of Regina faculty and students ever since, Math Central has earned many awards since its inception, and was cited as one of your major contributions to the advancement of mathematics and mathematics education at the local, regional, and national levels when you received the 2008 Canadian Mathematics Society (CMS) Adrien Pouliot Award and the 2008 Pacific Institute for the Mathematical Sciences (PIMS) Education Prize.

Could you describe what Math Central offers for students and teachers of mathematics, and what sparked its creation? How has it evolved over the years?

In 1995, the World Wide Web was in its infancy and there were very few educational websites. Denis Hanson (a mathematician), Mhairi (Vi) Maeers (a mathematics educator),

and I, all at the University of Regina, saw the possibility of creating a mathematics education website for use by K-12 students, teachers, and parents. We also saw this as a way to introduce the mathematics education students at the University of Regina to using the web as a teaching resource. This may seem strange now, but it was before schools, school boards, or even the Department of Education even had their own websites.

The resulting website, Math Central, began with four services: The Resource Room, a place where teachers could share teaching ideas; Quandaries and Queries, a question and answer service; Teacher Talk, a mailing list for teachers; and The Bulletin Board, which contained, among other things, links to mathematics teachers' organizations across the country. From the beginning, Teacher Talk and the Bulletin Board were infrequently used, and Teacher Talk was soon dropped and replaced by other services. The material in the Resource Room and in Quandaries and Queries are stored in searchable databases. The initial development of Math Central was supported by a grant from the Multimedia Fund of the Department of Education and support from the Faculties of Education, Science, and Graduate Studies and Research. This and other funding that Math Central has obtained over the years has been used largely to hire students, mainly students in the Faculty of Education, for part-time positions during the academic year as well as for summer positions.

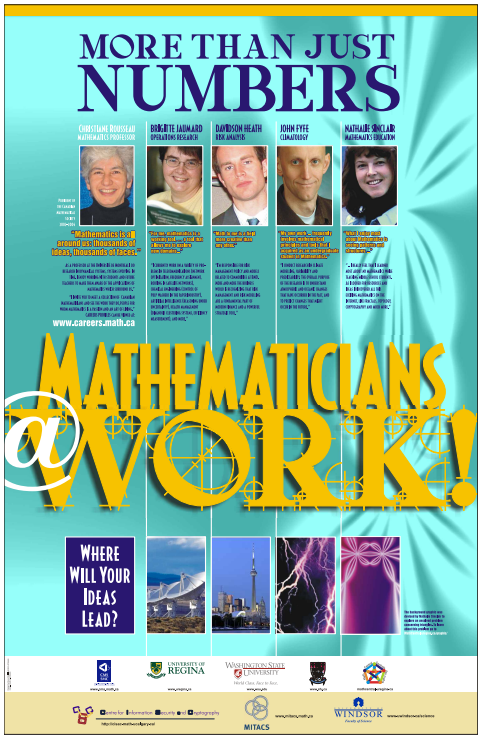
Most of the items in the Resource Room come from Saskatchewan teachers, many from pre-service teacher projects in mathematics education courses. Others were gathered from visits to teachers in their classrooms and from the former SMTS publication, *Ideas and Resources for Teachers of Mathematics* (see the Math Central website for select issues). When the Stewart Resource Centre at the Saskatchewan Teachers' Federation went from distributing paper copies of its resources to digital distribution, they gave all of their mathematics material to Math Central for posting in the Resource Room. Approximately 10% of the items in the Resource Room are in French.

Quandaries and Queries has been by far our most active service. The primary goal is to respond to students' questions with ideas, hints, or links to responses to similar questions to help them solve the problems themselves. The responses are supplied by teachers, university faculty and students across the country. Each response is formatted into a web page and entered into the database by an editor. The fact that many of the responses are read by the responder and an editor gives some degree of quality control to the responses. The majority of questions do come from students, but we also receive questions from parents, especially addressing topics that were not in the curriculum when they were in school. One surprise has been the number of questions received from the general public. These questions are wide-ranging: for example, determining the number of acres in an odd-shaped lot, scheduling foursomes for a golf vacation, questions from artists, questions about carpentry, calculating the amount of fertilizer in a bin, and much more. Using the keyword search, in Quandaries and Queries you can find some of these questions from the general public and our responses by entering the phrase math beyond school. You can also drill down somewhat in the database by adding a keyword. For example, the phrase math beyond school trigonometry will bring up questions where we have used trigonometry in our responses.

From 1995 to 2002, Vi Maeers and I hired mathematics education pre-teachers to work on Math central, visited schools to invite teachers to share their lessons in the Resource Room, and presented our work to mathematics teachers' conferences in Canada, the United States, and Europe. Other mathematics education web sites came into existence over this period

that allowed teachers to share their work, and Saskatchewan teachers were at the forefront of this movement.

Over the years, additional services have been added to Math Central. One is Mathematics with a Human Face. A quilt of photographs of people with a degree in mathematics was created, and clicking on a face on the quilt brings up a PDF file that profiles that mathematician and his or her career. These pages are designed to be printed on an 8.5" by 11" page so that a teacher can post them in his or her classroom. As part of this initiative, we also produced a poster, titled *Mathematicians at Work*, which was mailed to every high school and public library across the country. A pamphlet was also developed and distributed at teacher conferences and math camps. The quilt, poster, and pamphlet were produced in both English and French.



Mathematicians at Work poster, which can be downloaded at mathcentral.uregina.ca/HumanFace/careers/poster.html

In 2000, a Problem of the Month section was started by Chris Fisher with help from Claude Tardif and later from Martin Argerami. A problem was posted at the beginning of each month with an invitation for solutions from anyone interested; at the end of each month, a solution was posted, with credit given to all who correctly solved the problem. From the beginning, the problems and solutions appeared in both English and French, and in 2005 a Spanish version was added. In 2012, Chris Fisher retired and our Problem of the Month section ceased to be active. However, the problems and solutions still exist on the site.

One more service I want to mention is Math Beyond School. This is our attempt to help answer the question "When will I ever use this?" The articles span a wide range of topics and mathematical concepts. Their purpose is to provide some examples of how math is used in everyday living and in specific occupations.

Two companion sites to Math Central are Aboriginal Perspectives and Math on the Move. These are mathematics education projects undertaken with Kathy Nolan, a colleague in the Faculty of Education at the University of Regina.

Math Central, and in particular Quandaries and Queries, is not as active as it was a few years ago. My feeling is that part of the reason for this is the advent of social media. Facebook, Twitter, and the other social media networks provide students and parents a more immediate way to obtain responses to their mathematical questions than we can supply, and the responses come from people they know and trust. Our site is still very active, but most of the hits are to items in our databases that come from searches using Google, Bing, or other search engines.

In recent years, you have also been involved in work and research in the interface between mathematics and Aboriginal culture, perspectives, and ways of knowing. In 2009, for example, you worked with students from the Saskatchewan Urban Native Teacher Education Program (SUNTEP) to develop mathematics activities with a distinctly Aboriginal focus, an initiative which has since then been expanded (see Nolan & Weston, 2015). More recently, you have been involved with the development of Aboriginal Perspectives (http://aboriginalperspectives.uregina.ca/), a companion site to Math Central featuring videos, lessons, games, and other information for incorporating Aboriginal culture, perspectives, and ways of knowing in the teaching and learning of mathematics.

How did you become involved in this effort? Has your work and research in the intersection of mathematics and Aboriginal culture changed, or added, to your understanding of the nature of mathematics and what it means to "do" mathematics? (If so, how?)

I don't really know how I first became interested in mathematics and Aboriginal culture, but I have been interested in anthropology for a long time, so it is natural that I would look at the relationship between mathematics and culture. In 2001, Karen Arnason (an instructor at SUNTEP in Regina), Judith (Judi) McDonald (a fellow mathematician), Vi Maeers, and I presented a paper entitled "Interweaving Mathematics and Indigenous Cultures" at a meeting of New Ideas in Mathematics Education, and then in 2002, Judi and I presented a paper at a meeting of the Second International Congress on Ethnomathematics. These two papers led me to look at the work by the entnomathematics group in North America to see what had been done on the mathematics of the First Peoples of the Americas. I found many references to the mathematics of the Indigenous people in South America and in the southern United States, but very little concerning the mathematics of the First Peoples in our part of the world. This gap became significant to me when I began to hear concerns from teachers in trying to meet the curriculum requirement that they include an Aboriginal perspective in their mathematics classes. The Aboriginal Perspectives web site was an attempt to address these concerns.

In 2009, I hired a student from SUNTEP, a second a student from the Faculty of Education, and a third from our School of Journalism to create lesson ideas built around video clips from both interviews with individuals in the Aboriginal community and traditional Aboriginal activities. In the summers of 2010 and 2011, Kathy Nolan and I worked with students from SUNTEP and the First Nations University of Canada to develop workshops to aid teachers of Grades 3 to 6 with including an Aboriginal perspective in their mathematics classes. The students facilitated these workshops to teachers in Regina in 2010 and 2011 and since then, Kathy and I have delivered these workshops to teachers in various parts of Saskatchewan and in Yellowknife.

> "We tend to see mathematics as procedural, "algebraic," and acultural, but I now see it as much more than that."

This work on Aboriginal Perspectives and my contact with the ethnomathematics group has changed my understanding of the nature of mathematics. We tend to see mathematics as procedural, "algebraic," and acultural, but I now see it as much more than that. I love the beauty and elegance of abstract mathematics, but I also now see mathematics through the lens of the holistic nature of Indigenous knowledge. Kathy Nolan and I saw the challenges and opportunities that this can create for teachers in our work in Yellowknife. There is a document in the Northwest Territories called the Dene Kede Curriculum, which was developed by elders and teachers across the territories. Teachers are expected to link their mathematics lessons to outcomes in the Alberta curriculum as well as to articles in the Dene Kede curriculum.

Do you foresee a danger of activities, such as playing Aboriginal games of chance, being decontextualized and used simply as an "add-on" (and a curriculum requirement), rather than an element of a greater effort to incorporate Aboriginal culture, perspectives, and ways of knowing in the classroom? In your view, what would the latter entail, and how might teachers grow in their capacity to do so?

> "I do worry about our activities being used as an "add-on" to satisfy the curriculum requirements… I encourage teachers to invite Aboriginal elders into their classes and to listen carefully to what they say."

Yes, I do worry about our activities being used as an "add-on" to satisfy the curriculum requirements. In our workshops, we implore the teachers to read the background information we have collected, encourage them to search out other background information, and to share it with their students. I am not an expert on Aboriginal ways of knowing and I encourage teachers to invite Aboriginal elders into their classes and to listen carefully to what they say.

In wrapping up this interview, I'd like to ask you about your current work and interests. For nearly 20 years, in addition to maintaining the Math Central website, you were active in responding to students, teachers, and the general public who sent in mathematics questions to Math Central—and are still doing so! In what other ways do you continue to be involved with the mathematics and mathematics education communities in Saskatchewan? Have you pursued any new interests (mathematical or otherwise) since your retirement?

Much of my work, particularly in Aboriginal Perspectives and Math on the Move, has been done since I retired in 2005. I still respond to questions that come to Quandaries and Queries, many under the pen name Penny Nom, and I continue to work on the maintenance of the websites. One of the challenges of retirement is that I miss the contact with students, but I have been able to maintain it somewhat through Aboriginal Perspectives and Math on the Move. The enthusiasm and ingenuity of our students is a resource that I have relied on to my benefit and to the benefit of the students. In all of my mathematics education endeavours, most of the work has been done by students.

Other than mathematics activities, I am the treasurer of a retirees group at the University of Regina. This group has raised a substantial amount of money for a scholarship fund and I chair the scholarship committee. We have recently moved from our house in Regina to a lakefront property in the Qu'Appelle Valley, where I spend time gardening and woodworking. I am also an avid knitter.

Thank you, Dr. Weston, for taking the time to share your experiences and perspectives. We look forward to continuing the conversation in the future!

Ilona Vashchyshyn

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Quilt Block Symmetries [1]

Matt B. Roscoe and Joe Zephyrs

Pull on the threads of congruence and similarity in a series of lessons that explores transformational geometry.

Geometric transformations have long been topics of middle school mathematics. Generations of middle school students have learned to reflect, rotate, and translate geometric objects. Historically, though, the mathematics of "movement" might have been considered a departure from other more central middle-grades geometric content areas, such as measurement, congruence, and similarity. But in the era of the Common Core State Standards for Mathematics (CCSSI 2010), the study of reflection, rotation, and translation have been given special importance. Consider the introduction to the high school geometry domain in the Common Core State Standards for School Mathematics (CCSSM):

> The concepts of congruence, similarity, and symmetry can be understood from the perspective of geometric transformation. Fundamental are the rigid motions: translations, rotations, reflections, and combinations of these, all of which are here assumed to preserve distance and angles (and therefore shapes generally). Reflections and rotations each explain a particular type of symmetry, and the symmetries of an object offer insight into its attributes. (CCSSI 2010, p. 74)

The document makes it even more explicit in the next paragraph, describing the approach to congruence, in which "two geometric figures are defined to be congruent if there is a sequence of rigid motions that carries one onto the other" (p. 74). Like congruence, the study of similarity in high school also rests on students understanding transformation by defining similarity as a sequence of rigid motions followed by a dilation, which "lead[s] to the criterion for [angle-angle] triangle similarity" (p. 74). These passages make it clear that one crucial element of students' success in high school geometry is a firm understanding of transformation, which must be acquired in the middle grades.

> "The study of transformation is a fertile setting in which students can make sense of problems, reason abstractly, construct viable arguments, and look for structure."

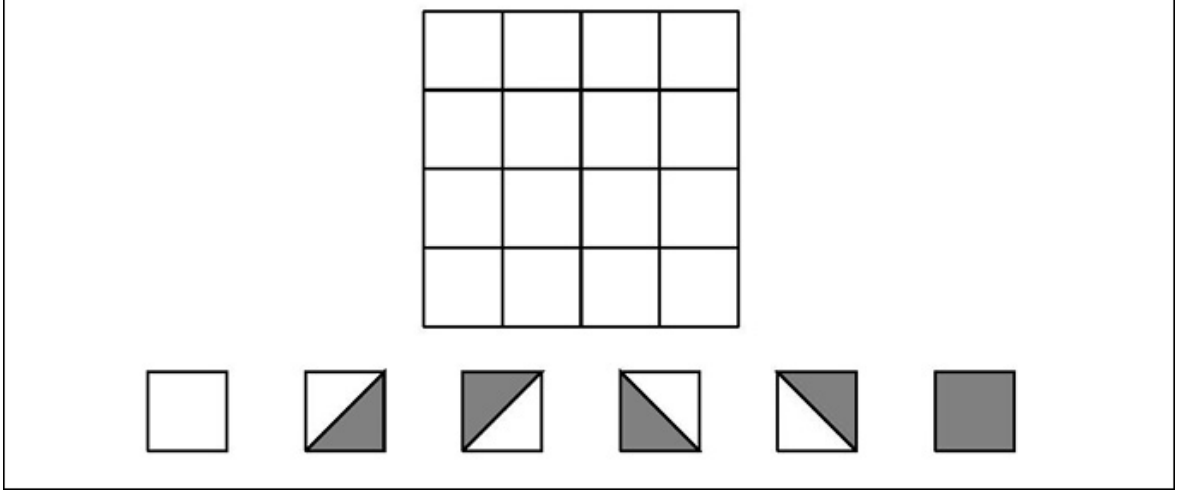
One difficulty associated with teaching transformations in the middle grades is the facilitation of inquiry-based learning environments in which students explore and investigate properties of transformations in objects of their own creation. The study of transformation is a fertile setting in which students can make sense of problems, reason abstractly, construct viable arguments, and look for structure, all practices that are encouraged in the Common Core's Standards for Mathematical Practice (2010). In addition, the study of transformations has long been associated with tools of inquiry (witness the use of patty paper, the Mira™, and interactive geometry software). But few are the opportunities where student-generated examples are the focus of mathematical investigation. To this end, we created a series of mathematical tasks that provided students with the opportunity to construct

understandings of transformation through an investigation of quilt block symmetries. The following is a description of these tasks and a demonstration of their use in an eighth-grade classroom.

The Setup

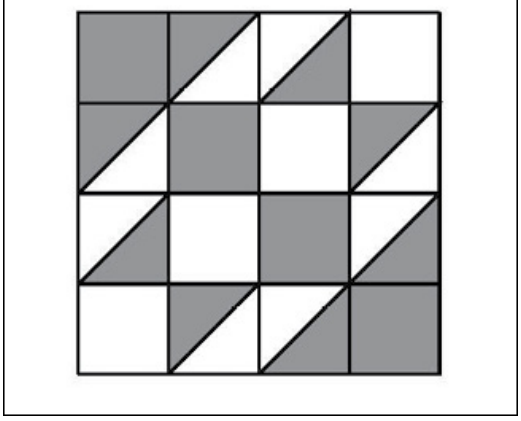
Imagine that you are a quilt maker. Each quilt you construct is composed of individual quilt blocks, which are squares that are filled and colored. Suppose that your quilt-making process restricts each quilt block to a 4 × 4 grid of squares that are filled in one of six ways, as shown in Figure 1.

Fig. 1 A quilt block grid and shading restrictions were given to students.



One possible quilt block constructed according to these "rules" is shown in Figure 2.

Fig. 2 This example illustrates a completed quilt block.

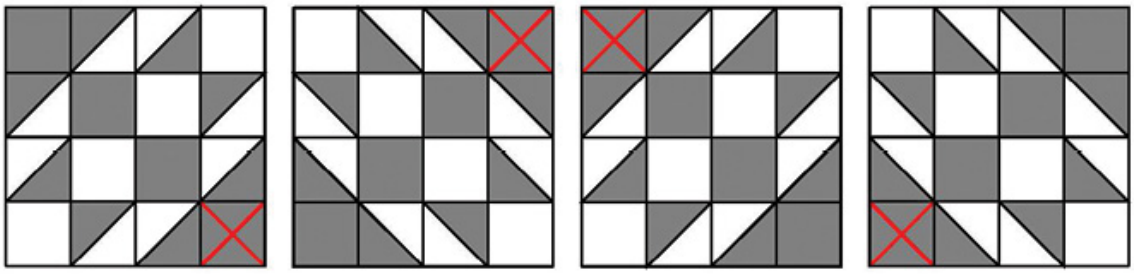


Since each quilt block is constructed in the shape of a square it can have, at most, the symmetries of a square:

- 90-degree rotational symmetry
- 180-degree rotational symmetry
- 270-degree rotational symmetry
- Reflective symmetry in a line defined by the midpoints of opposite sides of the boundary square
- Reflective symmetry in a line defined by the opposite vertices of the boundary square

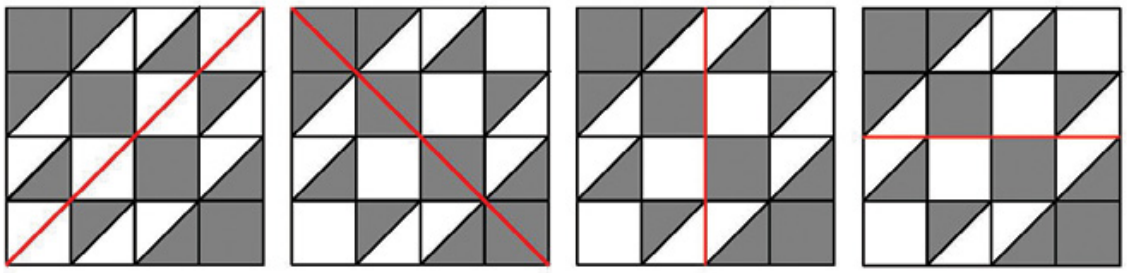
With these possibilities in mind, we can "classify" the example found in Figure 2. The quilt block only reproduces itself when rotated 180 degrees, not at 90 degrees or 270 degrees. Thus, the quilt block does not possess 90-degree or 270-degree rotational symmetry, but does possess 180-degree rotational symmetry. This result is shown in Figure 3. Note that a red "X" has been added to one cell of the quilt block to clarify how the block has been rotated.

Fig. 3 A red X helped students keep track of rotation, to then identify rotational symmetry.



The example quilt block can also be analyzed for reflective symmetry. We see that the block can be reflected across either of its two diagonals and reproduce itself. However, when the quilt block is reflected across a line formed by either of the pairs of opposite midpoints of the boundary square, the block fails to reproduce itself. We conclude that the example block has two reflective symmetries in the lines defined by the diagonals of the boundary square. This result is summarized in Figure 4.

Fig. 4 Reflective symmetry was also examined and identified.



After considering every possible line and rotational symmetry, we can conclude that the example quilt block can be classified by its symmetries as "D1, D2, 180" because it has two reflective symmetries in both diagonals of the boundary square and 180-degree rotational symmetry. The exercise opens the door to a world of new mathematical questions:

- How many D1, D2, 180 quilt blocks exist?
- What other types of quilt blocks exist?
- If a quilt block has two different reflective symmetries, does it always have a rotational symmetry?
- If a quilt block has a rotational symmetry, does it always have at least one line symmetry?

These questions and others were explored by eighth-grade students at a Montana middle school.

Day 1: Investigating and Classifying

On the first day of the activity, students were given a blank quilt block like that shown in Figure 1. After a brief discussion of the restrictions associated with filling each of the 16 cells, each student was asked to create his or her own design. Immediately, students began designing a personalized quilt block. After about ten minutes devoted to creation, the mathematical discussion began. Students were first challenged to compare their quilt block with a partner's block. Partners were asked to discuss how the two examples were similar and different in terms of the symmetries present in each. Many interesting conversations arose, which naturally primed a classification scheme that was motivated by the question, "What sorts of symmetries can a quilt block possess?"

Reflective symmetries were the first to be recognized. Students decided that each block could have one of four line symmetries: horizontal, vertical, and two diagonals. Some students objected to the use of horizontal and vertical as "labels" for lines of symmetry because of the problem of orientation. That is, what one might call a horizontal line of symmetry another might call a vertical line of symmetry under a different orientation. It was decided that the ambiguity could be resolved by recognizing that the two symmetry labels were interchangeable.

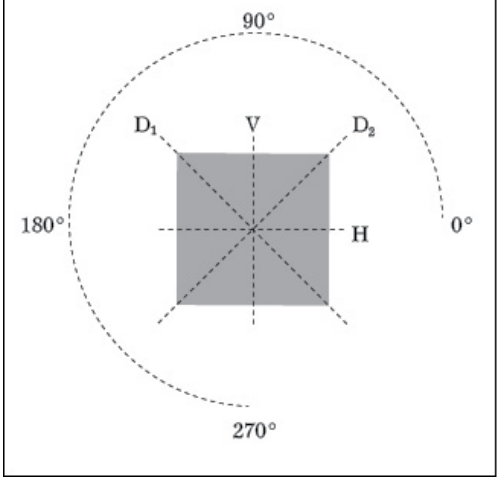
Rotational symmetries were noticed next. This transformation seemed less intuitive to students. Students identified rotational symmetries of 90, 180, 270, and 360 degrees. We pursued a discussion of 360-degree rotational symmetry with the question, "Which quilt blocks that you have constructed possess 360-degree turn symmetry?" When all answered affirmatively for all blocks, we pressed students further, "Would every possible quilt have 360-degree rotational symmetry?" Students reasoned that since a 360-degree turn of any quilt block is a "full turn," and since every full turn returns a quilt block to itself, all blocks would possess this symmetry. Further, since the full 360-degree turn returns the quilt to its original orientation, it was the same as a 0-degree rotation, that is, no rotation at all. For these reasons, students decided not to "count" 0 degree and/or 360 degrees in their classification system. It should be noted that disallowing 0-degree or 360-degree turn symmetry agrees with most elementary school definitions of rotational symmetry as being strictly less than 360 (i.e., Billstein, Libeskind, and Lott 2010, p. 980). However, in the modern mathematics of group theory, the 0-degree rotation is included as the identity transformation—behaving in a similar manner to 0 in addition or 1 in multiplication.

Once a list of these available symmetries had been generated, the class decided that these symmetries would be symbolically represented according to the following:

- 90: 90-degree rotational symmetry
- 180: 180-degree rotational symmetry
- 270: 270-degree rotational symmetry
- H: Reflective symmetry in a horizontal line (interchangeable with V)
- V: Reflective symmetry in a vertical line (interchangeable with H)
- D: Reflective symmetry in a diagonal line (two possible)

Again, here we note that the student-generated classification system is at odds with modern group theory in its classification of diagonal line symmetry. Whereas the student-generated system labels both diagonal symmetries with the same algebraic representative, D, modern group theory would prefer each diagonal to be distinguishable similar to horizontal and vertical labels (i.e., H and V). Teachers who are re-enacting this lesson might opt to lead students in this direction. To this end, a summary of the available symmetries of the square, consistent with modern group theory, is displayed in Figure 5.

Fig. 5 The available symmetries of the square are highlighted by this diagram.



Our pedagogical decision not to promote this level of specificity was an attempt to allow students to build and test a system sufficient for the classification of the quilt blocks they had constructed; the system they invented was suitable for this task.

With the classification system decided, students were asked to classify their quilt blocks. Among the blocks constructed by the fourteen students, the following types were found:

- D, D, 180
- H, V, 180
- H
- H, V, D, D, 90, 180, 270 (also called "All")
- 90, 180, 270
- None

Day 1 concluded with a brief discussion of questions for future inquiry, the most pressing of which was the open question of the existence of other classes of quilt blocks.

Day 2: Sorting Quilt Blocks and Creating Sets

Students' newly acquired knowledge of quilt block classification was reinforced on day 2 in a quilt-block-sorting task. A Mira, a transparent mirror-like device that aids in the analysis of reflective transformation, was given to each group as a tool for inquiry for the activity. Pairs of students were then given a complete set of 28 quilt blocks, each block having a unique number from 1 to 28 written on the back. They were instructed to use the classification system that they had developed on day 1 to classify each of the quilt blocks into sets with exactly the same symmetries. These 28 quilt blocks are displayed in Figure 6.

Readers are encouraged to attempt this classification task before reading on.

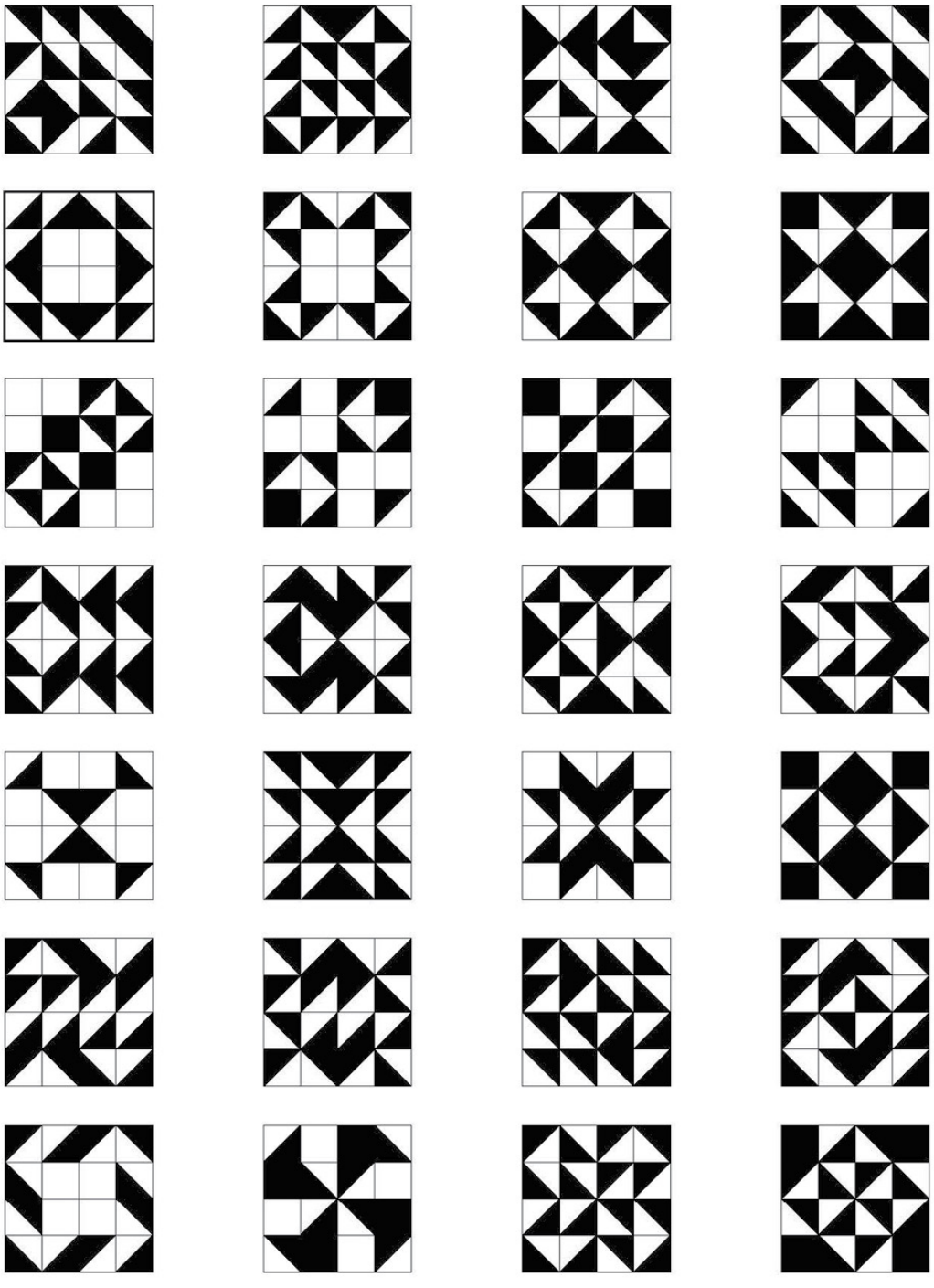
Although students were quick to begin the task, the time to completion was highly variable. The fastest groups finished in about fifteen minutes, whereas other groups took nearly twice that time. Groups that finished early were challenged to investigate further and given the following prompts:

- Each quilt block set should have the same number of members. Do all your sets have the same number of members?
- Did you discover any new sets to add to those we discovered yesterday?
- Do you think that any other sets exist? Why or why not?

Once all groups had finished the quilt block classification task, results were shared. Although most pairs of students found similar results, some disagreed. These disagreements gave students an opportunity to either critique or defend their mathematical understandings. Eventually these conflicts were resolved, and the class came to a group consensus. For the reader who has attempted the task, each row of quilt blocks found in Figure 6 has the exact same symmetries. Using the students' previously developed symbols and ordering by row number in Figure 6, seven different symmetry classes of quilt blocks were found, each with four members:

- D
- H, V, D, D, 90, 180, 270 (also called "all")
- D, D, 180
- H
- H, V, 180
- 180
- 90, 180, 270

Fig. 6 These 28 quilt block designs were given to students to sort by symmetry.



Students noted that two new classes had been "discovered" in the activity: D and 180.

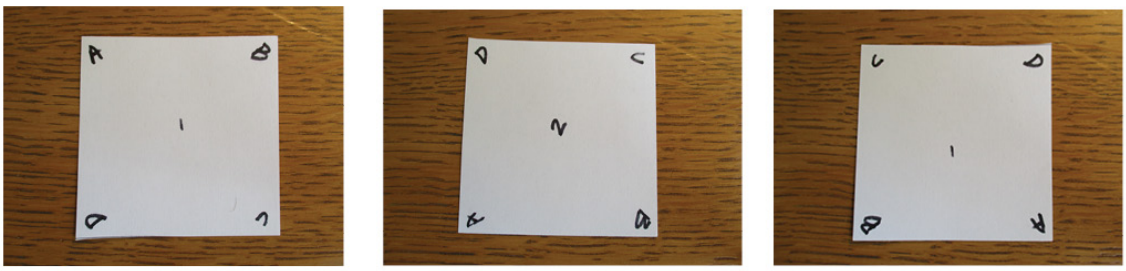
Once the sorting activity was completed, students were assigned a homework task. Each student was given a sheet of empty quilt blocks and instructed to create a set of 7 quilt blocks, 1 of each type that was discovered in the sorting activity. Students were told that their 7 examples would become part of a classroom set of seven quilts, each consisting of quilt blocks of the same class that would all be sorted once they were completed. Anticipating this future use, it was decided that each student would complete his or her set using a single color so that each quilt block's maker could be identified by color and so that each final quilt would be aesthetically multicolored.

Day 3: Looking for Other Symmetry Classes

On the first day of the activity, we discovered 5 symmetry classes that were represented by student-generated examples. During the sorting activity, 2 more classes were discovered. A few students started to ask, "Why do we only have 7 of them?" and "Are there any others?" Day 3 was devoted to answering these questions.

At the beginning of class, every student was given a square note card and instructed to label the four corners of the front of the card A, B, C, and D, moving counterclockwise, starting from the top left. They were then asked to label the four corners of the back of the card as A, B, C, and D as well, so that each physical corner of the card had the same label. To distinguish easily between the sides, a student recommended that we place a 1 in the center of the first side and a 2 in the center of the second side. An example was created in front of the class to avoid mistakes in labeling (see Fig. 7).

Fig. 7 A composition of horizontal and vertical reflection yielded a 180 degree rotation.



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(a) The original orientation

(b) Reflected in a horizontal line

(c) A reflection of (b) in a vertical line yielded the same result as a 180 degree rotation of the original orientation

Students were then asked to demonstrate their understanding of each of these symmetries using the note card manipulative. Students demonstrated 90-degree rotational transformation by making a one-fourth turn counterclockwise. Similarly, they demonstrated horizontal reflection by flipping the card over across its horizontal axis. Once each movement corresponding to a transformation of the square was familiar, students were encouraged to explore the effect of repeating a transformation or the effect of combining two dissimilar transformations. They were asked, "Would new transformations arise?"

Starting with their card in its original orientation (A, B, C, and D, clockwise from top left), students first explored the properties of a quilt block with 180-degree rotational symmetry by applying a 180-degree rotational transformation (always counterclockwise) to their card.

Applying the transformation a second time returned the card to its original orientation. Students discussed this result. They decided that since repeated applications of 180-degree rotations only produced 180-degree rotations, or resulted in the card being in its original orientation, a "quilt block class" (some preferred the term "family") possessing only 180-degree rotational symmetry was "allowed," since combining 180 with itself failed to produce any "new" transformations. Similar results were found for a horizontal reflective transformation (interchangeable with V) and a diagonal reflective symmetry. Quilt block families possessing only horizontal reflective symmetry or only diagonal reflective symmetry were also "allowed."

We posed this question to the class, "Why did we not list a family with solely 90-degree rotational symmetry?" Using their cards as a manipulative, students began by rotating their card 90 degrees. Students quickly noticed that they would need a 270-degree rotation to return to the original orientation. An important connection was made that 90 degrees and 270 degrees were tied together and that 90 degrees alone did not belong on the list. But as one student quickly pointed out, the list did not include a group consisting exclusively of 90 and 270. This was resolved by agreeing that if a quilt block had 90-degree rotational symmetry, then it must also have 180-degree and 270-degree rotational symmetries because 180 can be produced by putting two 90-degree rotations "together" and 270 can be produced using three 90-degree rotations "together." This action of "putting together" available symmetries to produce new ones was termed "composition" or "composing." We concluded that any quilt block with 90-degree rotational symmetry must also have 180-degree and 270-degree rotational symmetry. This confirmed the quilt block class "90, 180, 270" and disallowed many other types (for example, the class "90, 270" cannot exist).

Other logical necessities were explored in a similar fashion. By composing a horizontal and vertical reflection, as in Figure 7, it was discovered that a 180-degree rotation was produced, which confirmed the "H, V, 180" quilt block class and disallowed many other types (for example, the class "H, V" cannot exist). By composing the two available diagonal reflections, it was discovered that 180-degree rotation was also produced, confirming the class "D, D, 180" and disallowing many other types (i.e., D, D). Continuing in this fashion and using the card as a manipulative, the class validated the presence of the 7 types of quilt blocks discovered on day 1 and day 2 while systematically excluding any others. This activity was particularly rich in exploration and discovery, although some students struggled with the level of abstraction. For this reason, having students work in mixed-ability groups on this activity is highly advised.

Day 4: Completing the Classroom Quilt Categorization

On day 4, students arrived with their complete set of 7 quilt blocks, 1 of each type. Since there were fourteen students in the class, and it was agreed that either a 1×14 or a 2×7 quilt would not be very pleasing to the eye, we had constructed two extra sets each, with 7 quilt blocks, which were added to the students' quilt blocks so that the 16 total sets, once sorted, could be organized into 7 quilts each arranged in a 4×4 array.

The $16 \times 7 = 112$ quilt blocks were gathered together and shuffled at a large table. Students were then given the task of sorting the 112 examples into 7 groups of 16 quilt blocks whose members all shared the exact same reflective and rotational symmetries. Figure 8 displays a time-sequence view of this process as it evolved in the classroom.

Fig. 8 This time sequence shows the students at work in the final quilt sorting activity.

(a) (b) (c) (d)

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Notice that students used columns ordered by color as a strategy to analyze the "completeness of categorization." Using this structural approach to the group effort, it was determined that two quilt block sets had "duplicates," thus making it necessary for the owner to "rebuild" a quilt block of the missing type. Once these issues had been resolved, students collected each multicolored set and glued them together to produce a classroom display of 7 quilts composed of quilt blocks possessing the exact same reflective and rotational symmetries. Finished quilts are shown in Figure 9.

Fig. 9 Some of the 7 finished quilts made by the students, each labeled with the symmetry of the blocks.

(a) H, V, 180° (b) 90°, 180°, 270°

(c) D, D, 180° (d) H, V, D, D, 90°, 180°, 270°

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The Importance of Geometry

Quilt blocks provide an interesting and aesthetic environment in which math teachers can support inquiry-based learning activities targeting transformational geometry. This knowledge is vital in the era of Common Core (2010), because students' understanding of the rigid motions is identified as prerequisite knowledge to their deepening studies in congruence and similarity in high school. But perhaps most attractive is the opportunity that quilt blocks offer for students to practice mathematics as mathematicians do: to make sense of problems and persevere in solving them, to reason abstractly, to construct viable arguments, to critique the reasoning of others, and to look for structure. The importance of the Standards for Mathematical Practice (CCSSI, pp. 6–8) cannot be understated in terms of their potential to renovate the mathematical inheritance of the next generation of learners. We are confident that the activity described herein has contributed to this renovation by offering students the opportunity to make sense of quilt block symmetries through tasks that encourage mathematical investigation, creation, and sense making.

MTMS Twitter Chat

Did you miss the Twitter chat about this article? We've got you covered! Here's a recap of the conversation. At 9:00 PM EST on the third Wednesday of each month follow #MTMSchat on Twitter for a new conversation about an article in the latest issue of *MTMS*.

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Re-Imagining Calendar in Primary: Developing Mathematical Reasoning Through Play and Conversation [2]

Carole Fullerton

Calendar – Past and Present

The Daily Calendar routine is a staple in many early primary classrooms. Through this routine, we expose students to patterns and counting, as well as to concepts of place value. At least, this is the intent. However, an overwhelming number of primary teachers with whom I've worked acknowledge that calendar time feels rote and unsatisfying – both for them and for their students. Many question the pedagogical value of the event, but wonder what might replace it. After all, aren't we "supposed" to do Calendar in primary?

Moving Forward

What we have learned about the brain, what we know about the ways in which children acquire mathematical concepts, and what research and our curriculum tell us about developmentally appropriate practice has lead us to reexamine the traditional daily calendar routine. My colleague Sandra Ball (Surrey SD36) and I had long felt that Calendar needed an overhaul and set to re-imagining what this might look like for our youngest learners. The result was a resource designed to promote more interactive daily mathematics experiences, available on my website at http://mindfull.wordpress.com.

In this free online resource, we present a more active, participatory version of "calendar" – a daily opportunity for students to truly engage with meaningful math concepts, to play with materials, to process, to think, and to problem-solve. The tasks, questions, and problems we have included are intended to inspire thoughtful math investigations into number, shape, measurement, and pattern. We call these experiences "**Daily Math Investigations**."

Re-imagining: Daily Math Investigations

Daily Math Investigations are an opportunity for students to think and play with mathematical ideas. Teachers present tasks and pose questions that are intended to promote curiosity about numeracy concepts. In opening up the kinds of questions we ask, we include more students in the learning of math, and help to address the diversity of learners in our classrooms. A combination of **entry tasks** and **rich routines** allow for balance between whole group, small group, and independent learning, providing a chance for students to explore the math at their own level. In designing entry tasks and rich routines, we considered the following:

"In opening up the kinds of questions we ask, we include more students in the learning of math, and help to address the diversity of learners in our classrooms."

[2] This article was previously published in *Vector: Journal of the BC Association of Math Teachers*, Volume 55, Issue 2. Reprinted with permission.

Timing
- How long is too long?
- How much time is just right?

We know that young learners have a limited attention span. For the learning to happen, our whole group carpet time must be short, and it must be spent wisely.

Activity level of the students
- Who's doing the talking?
- Who's doing the math?

Little children need to move, to touch, and to talk in order to learn. The richness of the math is lost when it is presented only orally. Introducing tangible materials to carpet time, providing opportunities for students to think-pair-share, and recognizing and celebrating students' "aha moments" are essential.

Grouping
- Whole group?
- Small group?
- Independent?

Daily Math Investigations do not need to be done all together, all the time. Consider opportunities for students to work in small groups, pairs, or even alone on a particular question or task.

Content
- What important math idea(s) will be explored?
- How does it address the range of learning needs?

Within the curriculum, there are several skills and concepts that require time to master. It makes sense to present these ideas over time and with intention in thought-provoking ways through a Daily Math Investigation! As they develop as thinkers throughout the year, students will engage with the important concepts again and again, seeing them through different, more evolved lenses.

Connectedness
- What connections are being highlighted?
- What math-to-math, math-to-self, and math-to-world connections can be made?

Students learn best – and remember more – when the learning they are doing is connected. Supporting students in thinking about how the mathematical idea you're exploring is related to another they are already familiar with is an important foundational aspect of learning. Connecting the ideas to students' own experiences is likewise critical – embedding the math in something relevant to your students is highly motivating!

Engagement
- How will I know if my students are learning?
- What kinds of questions keep students thinking?

In the past, students' experience of Calendar was, at best, minimally engaging. Being the "VIP" happened far too seldom for real learning to happen! As we evolve in our practice, it's important to consider the degree of engagement during this rich learning time. The engaging part of the task must be the math – the complexity of the question, the curiosity it inspires, and the conversations that emerge.

Assessment

- What can I learn about my students?
- What can I watch and listen for?

Daily Math Investigations are ideal opportunities for teachers to observe, listen, and reflect on what their young learners know and can do. As they wrestle with important math, students' thinking is exposed through their actions and words. Take advantage!

Thinking Through Tasks – Ideas for Daily Math Investigations

Entry Tasks

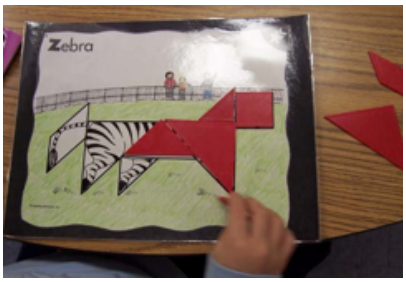
Entry tasks – What are they?

Entry tasks are exactly that – tasks that are prepared and waiting for students as they enter the classroom at the beginning of the day. Knowing that our students' minds tend to be the most fresh in the morning, presenting these problems and mathematical curiosities to students as they arrive makes sense. Moreover, they allow teachers to welcome and talk to their students as they transition into the learning space.

Entry tasks are invitational in nature. They are intended to inspire wonder and to encourage questioning. Students love these interesting questions and eagerly anticipate these morning tasks. These explorations can be very motivating – even for reluctant learners. Consider the following tasks:

Tangram puzzles

Use a complete set of 7 tangram pieces and the puzzles found in the resource (or other commercially available ones). Have students match pieces to the outlines. Encourage them to complete the puzzles in more than one way! Give students the language of flipping and turning to describe the translations they are using. Consider reading *Grandfather Tang's Story* by Ann Tompert as an introduction to these puzzles.



Hundred Chart Puzzles

Cut up a hundreds chart along the grid lines into 5-6 interestingly shaped pieces. Have students reassemble the pieces to make a complete chart. Photocopy hundreds chart puzzles onto coloured paper of various colours to keep the pieces distinct.

Scoop It!

Provide a set of small containers and unifix cubes. Have students fill the jars and then count their cubes to see which one hold the most. Older students should record the total number and make statements of comparison ("This one held three more than that one..."). On another day, switch the unifix cubes for puff balls, erasers, stacking chips, or foam counters

and have students explore again.

Tray of Treasures
Place a set of objects on a tray. Have students put them in order according to an attribute of their own choosing. Explore and discuss the attributes they used (length, width, mass, etc.).

Simple Partner Games
There is a wide array of quality games for practicing and mastering number relationships. Consider your own favourites, from Concentration, Go Fish, and Snap to games from BEAM, as well as those drawn from other core resources. Be sure that students know how to play these games before setting them out. Even a set of dice, a stack of counters, and a spinner can be used by students to play games of their own creation.

Rich Routines

Rich Routines – What are they?
Rich routines are explored in more structured ways. These questions – open-ended and interesting – are often posed during carpet time. Unlike a traditional calendar time, rich routines include far more opportunities for talk and modelling. Students engage with them in active ways and in a variety of groupings. The questions may serve as a springboard to other, more involved investigations, but the focus is on connectedness and content. The power in rich routines is in their potential to revisit important content over time.

All About Number
For this rich routine, select a number that is familiar to your students, and model with the whole group how to complete a set of prompts. For example:

17 is more than **12**.		**17** is too many **hats for my head**.
17 is less than **18**.	OR	**17** is too few **cookies**.
17 is the same as **10 and 7**.		**17** is just enough **friends**.

Do a think-aloud as you record your numbers to support students in understanding why you picked them. Invite some ideas from your students for a second number and record them. Then have students work collectively – in the whole group or in small groups – on numbers at their own, individual levels. For example, you might create a group of students and have them work on statements for the number 11, and have another group working on the number 20.

Consider your students and the number and kinds of sentence frames you use each day. Don't use them all at one go!

Line masters for thinking prompts designed to explore number, mass, capacity, time, and money are included in the resource for your use.

Counting Collections
Build opportunities into your daily routine to estimate and then count collections of different sizes. Start out with small collections (5-10 objects) and then increase the size gradually. Changing the size of the objects to be counted will provide novelty for students and will force them to think hard about their estimates. Consider using unifix counters,

small beads, marbles, cotton balls, pennies, pencils, or fun counters in the shape of animals.

Sort It Out!
Consider integrating a sorting task into your daily routine time. Start with 8-10 objects that share more than just colour-based attributes. Invite students to sort the objects in one way and have their peers guess their sorting rule. Then invite another student to sort the same collection again, using a different attribute. Celebrate the different ways we can sort a set of objects!

Traditional Calendar – What to Keep and What to Let Go

A monthly calendar gives us interesting information. We can use it to mark important events, like an upcoming holiday, a student's birthday or a school celebration. Highlighting these events on a calendar and counting the days until they happen is fun for students. That said, the abstract nature of a calendar – the repeating 7-day pattern of days in a week, the recursive aspect of the chart itself, and the seemingly random number of days per month – makes it virtually undecipherable for young students.

For many of us, calendar time (and all the activities associated with it) is ingrained in our script for primary teaching. It's important, however, to consider carefully the purpose of these tasks – and, more importantly, their effectiveness.

Consider the following:
- Are the pieces of your calendar time truly relevant?
- Are students talking?
- Are they engaged?
- Are they doing math?

If you answered "no" to any of these questions, give yourself permission to let that piece go. Choose instead tasks that get students engaged, thinking, and reasoning mathematically. You'll be glad you did!

To download a copy of the Daily Math Investigations document, visit Carole's online store at: http://mindfull.ecwid.com and navigate to the "Free Resources" section. For more mathematical teaching ideas, visit Carole's blog at: http://mindfull.wordpress.com

Carole Fullerton is an educational consultant working in Western and Northern Canada to promote thought-full mathematics teaching. In her work with teachers, schools, and districts she focuses on deep thinking through the big ideas in mathematics, linking good questions and manipulatives together to address diversity in engaging ways. Lesson study (learning rounds) forms the foundation of her professional development practice, allowing her to make pedagogical change visible to teachers from pre-K to 12.

Carole wishes to acknowledge Sandra Ball and her unwavering spirit of professional collaboration. Without her, this resource would not exist!

What Math Do You See in This Necklace? [3]

Anamaria Ralph

A family member gave me a beaded necklace thinking that I could use it in my Kindergarten classroom. I didn't think much of it until I looked more closely at it and noticed the math potential that it had. A few days later, I took it to school. Rather than placing it at one of the exploration areas, I held it up and asked students:

"What math do you see in this necklace?"

Their responses gave me insight into what they thought when looking at the necklace and gave me a deeper view into what they considered to be math.

D. A. suggested that "we can count all the beads."

H. S. said that "we could look for patterns" in the necklace.

A few students suggested that we could measure how big the necklace was. I asked them what they meant by big, and they agreed that they wanted to know how tall it was. (I should mention that this necklace could not be separated, as it was made of wire and was welded together.) I held up the necklace vertically and asked them if they wanted to measure it this way; then, I then placed the necklace down flat and asked them if they wanted to measure it that way. One student made a circular motion with her hand. I told them that if they wanted to measure how big it was around, it was called circumference.

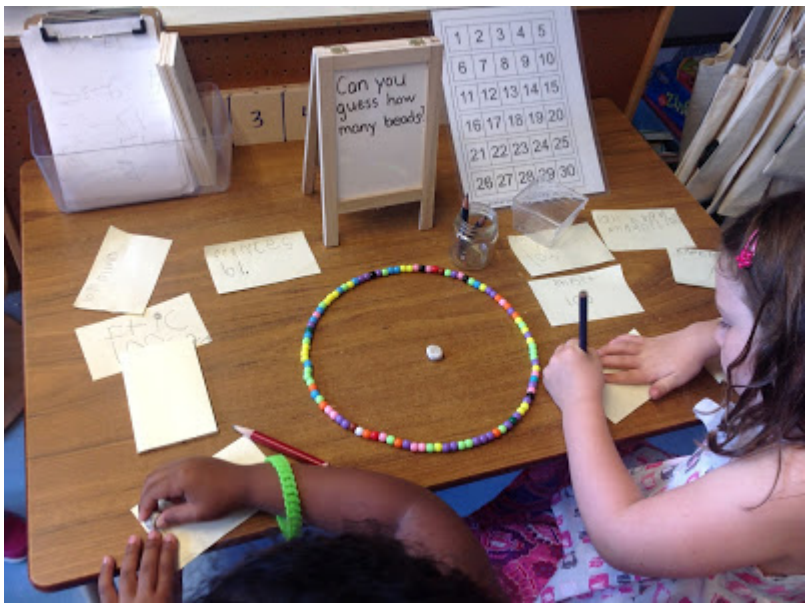
J. S. said "I think there is 100 beads!"

S. C. "I think there's 120 beads!"

I told them that this was called estimation: We could try to guess how many beads are on the necklace.

This little discussion amazed me—they came up with so many math concepts, all stemming from looking closely at a simple necklace. I decided to use this opportunity to set up a little estimation provocation. I took out Post-It notes and told students that they could come anytime and guess how many beads were on the necklace. To make it more fun, I told them that whoever guessed the closest would win a prize!

[3] A prior version of this article was published on June 18, 2015 on Anamaria's blog, *Wonders in Kindergarten* (http://wondersinkindergarten.blogspot.ca/). Reprinted with permission.



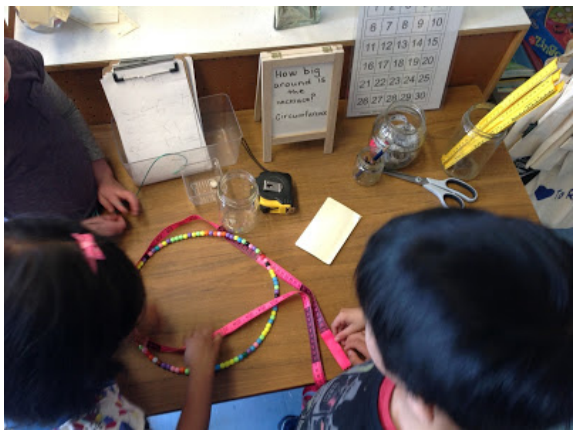
D. C. and J. S. were interested in counting the beads, so I told them to keep their answer a secret so we could figure out who was the closest to the actual number of beads.

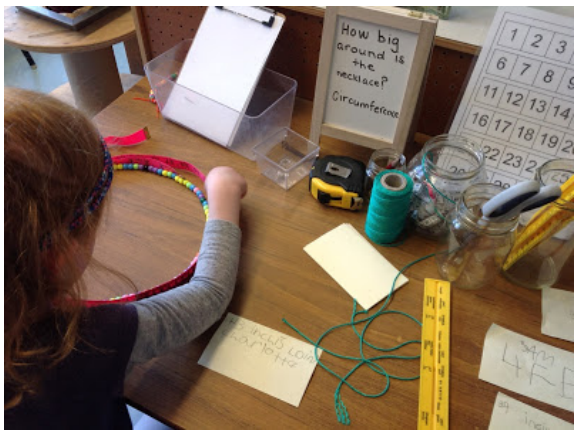
Almost all of the students took a guess at the number of beads that made up the necklace. When we came together as a group, I asked them what strategy they used to help them guess.

> P. I.: "I looked at the beads and I thinked my number and wrote it down on a sticky."
>
> O. M.: "I looked at the last bead and the first bead. It helped me to estimate."
>
> K. W.: "I looked at the whole circle of beads and I guessed my number and then I got a sticky and wrote my number."
>
> Z. G.: "What strategy I used is I heard the people that know the number saying another number and it wasn't the real number but it was close."
>
> C. D.: "I pointed at the beads and thought about the number."

We counted together and found that there were one hundred beads on the necklace. Three students had guessed the number exactly! I was very pleased that many students were close. However, some students guessed very low numbers, so we used this opportunity to demonstrate what that number of beads looked like in comparison to one hundred. (The three winners were gifted three little plastic flies, which they adored.)

The following day, students asked me if I could give them another challenge using the necklace. I asked them if they wanted to explore ways to measure how big around the necklace was (they did), set up another provocation and let them investigate it freely.





Once again, we came together to discuss and demonstrate our findings. I enjoyed watching the many different techniques students used to try to determine the circumference of the necklace. It was interesting to listen to the conversation that emerged from the demonstrations.

C. C.: "I used the measuring tape to measure."

K. W.: "I measured using the purple measuring tape."

S. C.: "So K. W. did it the same as C. C. I used rulers around the circle of beads. I got four feet. I know that one feet is one ruler."

P. I.: "I don't know if it's a good way because it is a square and we are supposed to measure a circle?"

K. W.: "I agree that it's not because some is not touching the circle."

O. S.: "It doesn't all fit in, it's not a square, it doesn't go around."

J. S.: "I agree with S. C. because it's a good way to do it."

E. E.: "Some of it is touching and some of it is not."

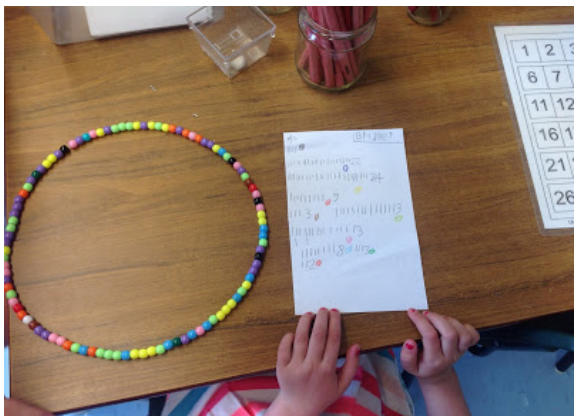
B. P.: "There is a triangle there and two triangles makes a square!"

E. E. & O. S.: "We used string to go around the necklace and then we measured the string and cut it, then we took the measuring stick and started at 0 and went to 98!"

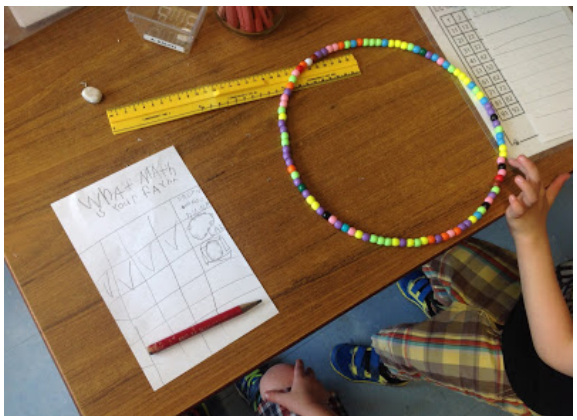
K. W.: "I think this was a good idea because they measured the string around it and then they checked on the measuring stick."

A. T.: "Yea it's a good idea, first they put it around and then put it on a ruler and made it straight on the thing to measure it."

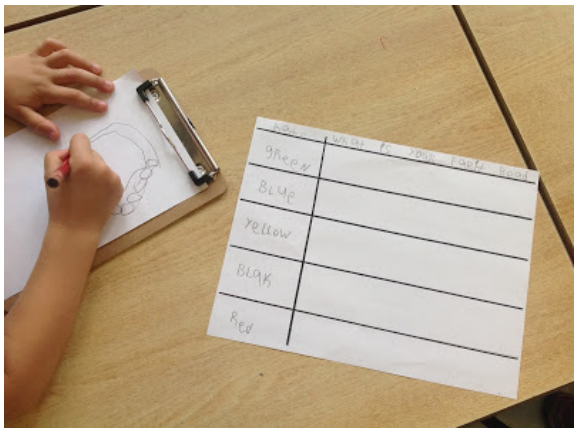
I thought this was the end of it, but the next day, more students asked if there was another challenge that I could give them to do with the necklace. This time, I told them to figure one out themselves. I was blown away by the concepts they discovered:



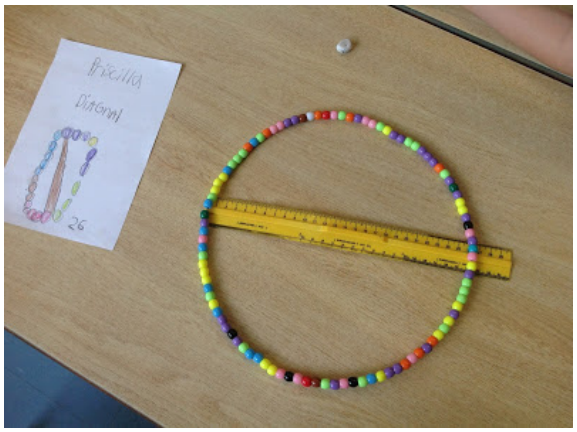
B. K. counted the different coloured beads



W. E. created a survey asking his peers what their favourite math technique was for the necklace



S. C. and K. W. created a survey asking their peers what was their favourite bead colour was



P. I. decided to measure the necklace diagonally

So much learning from just a simple necklace.

As an educator, I am constantly listening closely to my students and trying to tap into their interests, curiosities, and wonders. This simple necklace elicited so many questions that it was an authentic moment to grab onto. I have found that other items, such as colourful juice lids collected by students, have also naturally fostered sorting, counting, graphing, adding, and subtracting. Even special experiences such as pizza lunches, field trips, and birthdays have all lead to some wonderful and authentic math learning.

Don't be afraid to let the students guide you with their questions. It's moments like these that can foster rich, authentic learning of mathematics.

Anamaria Ralph is a Kindergarten teacher for the Toronto District School Board. She teaches at Maurice Cody Public School in Toronto, Ontario. She has taught Kindergarten for nine years and still regards each year as an exciting adventure where many wonders, explorations, and investigations take place. She is passionate about inquiry and play-based learning, and is greatly inspired by the Reggio approach to learning. She shares her students' learning with families and other educators on her classroom blog, www.wondersinkindergarten.blogspot.ca, and can also be reached on Twitter at @anamariaralph.

Intersections

In this monthly column, you'll find information about upcoming math education-related workshops, conferences, and other events. Some events fill up fast, so don't delay signing up!

For more information about a particular event or to register, follow the link provided below the description. If you know about an event that should be on our list, please contact us at thevariable@smts.ca.

Within Saskatchewan

Conferences

Saskatchewan Understands Math (SUM) Conference
November 4–5, Saskatoon, SK
Presented by the SMTS

Our own annual conference! The Saskatchewan Understands Math (SUM) conference is for math educators teaching in K-12 who are interested in curriculum, incorporating technology, number sense, and problem solving. Join us for two days packed with learning opportunities, featuring keynote speakers Max Ray-Riek of the Math Forum at NCTM and Grace Kelemanik of the Boston Teacher Residency Program. Registration includes lunch on Friday and a two-year SMTS membership. See the poster on page **Error! Bookmark not defined.**, and head to our website for more information and to register.

Workshops

Number Talks and Beyond: Building Math Communities Through Classroom Conversation
November 16th, Saskatoon, SK
Presented by the Saskatchewan Professional Development Unit

Classroom discussion is a powerful tool for supporting student communication, sense-making and mathematical understanding. Curating productive math talk communities requires teachers to plan for and recognize opportunities in the live action of teaching. Come experience a variety of classroom numeracy routines including number talks, counting circles, quick images and more. Take math conversations to the next level by strengthening your skills as a facilitator of classroom discourse and student thinking.

See https://www.stf.sk.ca/professional-resources/professional-growth/events-calendar/number-talks-and-beyond-building

Number Talks and Beyond: Building Math Communities Through Classroom Conversation
January 17th, Regina, SK

$110 (early bird), $150 (standard)
Presented by the Saskatchewan Professional Development Unit

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See https://www.stf.sk.ca/professional-resources/professional-growth/events-calendar/number-talks-and-beyond-building

Technology Integration for Differentiation in Mathematics
January 19th, Saskatoon, SK
$110 (early bird), $150 (standard)
Presented by the Saskatchewan Professional Development Unit

Are you interested in using technology to help differentiate your mathematics classroom? Workshop participants will be introduced to various blended learning structures, then focus on the station rotation and flipped classroom models. Whether you have one device or a classroom of devices, these two classroom structures are beneficial to increasing student engagement and to providing opportunity for teachers to have individual and small group instruction. The idea of using technology to create differentiated opportunities through adaptive instructional websites and math and presentation-related apps will be explored and connected to curricular outcomes, student learning progressions and assessment.

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See https://www.stf.sk.ca/professional-resources/professional-growth/events-calendar/technology-integration-differentiation

Early Learning With Block Play – Numeracy, Science, Literacy and So Much More!
January 25th, Saskatoon, SK
Presented by the Saskatchewan Professional Development Unit

This is a one-day workshop for early learning educators from prekindergarten, kindergarten and Grade 1 to join together, discover and deepen their understandings around the many foundational skills that children develop during block play. Through concrete, hands-on activities, participants will experience and examine the many connections between block play and curricular outcomes, and the current research on the topic. Participants will have opportunity for reflection on their current practice, planning for block play and for creating a network of support.

See https://www.stf.sk.ca/professional-resources/professional-growth/events-calendar/early-learning-block-play-numeracy-2

Extending Early Learning Block Play into Project-Based Inquiry
January 27th, Yorkton, SK
Presented by the Saskatchewan Professional Development Unit

This one-day workshop for early learning educators from prekindergarten, kindergarten and Grade 1 will deepen understanding around the foundational skills that children develop during block play and extend that understanding into project-based learning in early years. Through concrete, hands-on activities participants will experience and examine the many connections between block play, curricular outcomes and project-based inquiry in early years.

See https://www.stf.sk.ca/professional-resources/professional-growth/events-calendar/extending-early-learning-block-play

Using Tasks in High School Mathematics
February 8th, Saskatoon, SK
Presented by the Saskatchewan Professional Development Unit

Using tasks in a high school mathematics classroom can provide rich opportunities for differentiated learning and authentic assessment. How do we choose tasks that meet both curricular outcomes and student needs? Tasks allow students to enter mathematics where they are at and extend their learning. In this workshop we will look at a variety of resources for finding good high school tasks. We will also reflect and discuss what planning and teaching moves can assist in maximizing student learning through mathematics tasks.

See https://www.stf.sk.ca/professional-resources/professional-growth/events-calendar/using-tasks-high-school-mathematics

Technology in Math Foundations and Pre-Calculus
February 9th, Saskatoon, SK
Presented by the Saskatchewan Professional Development Unit

Technology is a tool that allows students to understand senior mathematics in a deeper way. This workshop is designed to have math foundations and pre-calculus teachers experience a variety of technology tools that allow students to represent and visualize mathematics concepts. Tools highlighted are useful for students to explore, learn, communicate, collaborate and practice, in order to enhance their understanding of mathematics in secondary mathematics.

See https://www.stf.sk.ca/professional-resources/professional-growth/events-calendar/technology-math-foundations-and-pre

Beyond Saskatchewan

Innov8 Conference
November 16-18, St. Louis, MO
Presented by the National Council of Teachers of Mathematics

Join your peers at the inaugural Innov8 conference, November 16-18, in St. Louis, Missouri! This innovative and team-based professional development is centered around acquiring the necessary skills to provide high-quality mathematics education for learners of all abilities. Innov8 provides opportunities for attendees to receive hands-on experience implementing research-based mathematics education practices; connect with like-minded teachers facing similar problems of practice; collaborate to determine effective solutions to advance student learning; and return to the classroom, school, or district with an action plan and commitment to implement refreshed tools and techniques.

Note: Did you know that the Saskatchewan Mathematics Teachers' Society is an NCTM Affiliate? When registering for an NCTM membership, be sure to support the SMTS by noting your affiliation during registration.

See http://www.nctm.org/innov8/

NCTM Annual Meeting and Exposition
April 5-8, 2017, San Antonio, TX
Presented by the National Council of Teachers of Mathematics

Join more than 9,000 of your mathematics education peers at the premier math education event of the year! NCTM's Annual Meeting & Exposition is a great opportunity to expand both your local and national networks and can help you find the information you need to help prepare your pre-K–Grade 12 students for college and career success. Classroom teachers, administrators, math coaches, supervisors, college professors, and preservice teachers can all benefit from the sessions and learning at this event. Improve your knowledge and skills with high quality professional development and hands on activities; gain insights by connecting and sharing with like-minded educators; collect free activities that will keep students engaged and excited to learn; and learn from industry leaders and test the latest educational resources.

See http://www.nctm.org/Conferences-and-Professional-Development/Annual-Meeting-and-Exposition/

OAME Annual Conference: Now for Something Completely Different
May 11-13, Kinston, ON
Presented by the Ontario Association for Mathematics Education

This year's keynote speakers are Dan Meyer, well-known for his work integrating multimedia into an inquiry-based math curriculum, and Gail Vaz Oxlade, host of the Canadian television series *Til Debt Do Us Part*, *Princess* and, most recently, *Money Moron.* Featured speakers are George Gadanidis, Marian Small, Ruth Beatty, and Cathy Bruce.

See http://oame2017.weebly.com/; follow @oame2017 on Twitter for updates

Online Workshops

Education Week Math Webinars
Presented by Education Week

Once a month, Education Weekly has a webinar focusing on math. They also host their previous webinars on this site. Previous webinars include Formative Assessment, Dynamic vs. Static Assessment, Productive Struggling and Differentiation.

Past webinars: http://www.edweek.org/ew/webinars/math-webinars.html
Upcoming webinars:
http://www.edweek.org/ew/marketplace/webinars/webinars.html

SMTS Awards

Do you know a teacher who works tirelessly to use and promote sound mathematical pedagogy? A teacher who uses innovative teaching strategies to excite and inspire their students in math class? An individual or group who has had a tremendous and meaningful impact on mathematics education in Saskatchewan? **Nominate them for a Saskatchewan Mathematics Teachers' Society Award**!

This year, the SMTS is offering three awards to recognize excellence in mathematics teaching and leadership in Saskatchewan.

Our first award, the **Master Teacher Award**, is awarded to an experienced K-12 Saskatchewan teacher of mathematics who has garnered a reputation for teaching excellence and promoting sound mathematical pedagogy among peers, students, and parents (this year's changes to the Master Teacher Award are detailed on our website). To accompany the Master Teacher Award is the **Teaching Innovation Award**, whose purpose is to recognize teachers who regularly employ non-traditional teaching strategies and in turn foster student engagement. Our third award is a **Service Award** for a person or group who has created a significant and positive impact on mathematics education in Saskatchewan. Note that the recipient of an SMTS award is *not* required to be an SMTS member.

Take a moment to read through the award descriptions and to nominate one of your colleagues on our website. We are also working to round out our history of past winners; if you know of a past winner who is not on our list, please email evan@smts.ca.

We look forward to hearing from you!

Call for Contributions

Did you just deliver a great lesson? Or maybe it didn't go as planned, but you learned something new about the complexities of teaching and learning mathematics. Maybe you just read a book or attended a workshop that gave you great ideas for presenting a topic your students have always found difficult, or that changed your perspective about some aspect of teaching. **Why not share your ideas with other teachers in the province – and beyond?**

The Variable is looking for a wide variety of contributions from all members of the mathematics education community in Canada and beyond, including classroom teachers, consultants and coordinators, teacher educators, and researchers. Consider sharing a favorite lesson plan, a reflection, an essay, a book review, or any other article or other work of interest to mathematics teachers in Saskatchewan. If accepted for publication, your piece will be shared, as part of this periodical, with a wide audience of mathematics teachers, consultants, and researchers across the province, as well as posted on our website.

We are also looking for student contributions, whether in the form of artwork, stories, poems, interesting problem solutions, or articles. This is a great opportunity for students to share their work with an audience beyond that of their classroom and their school, and for teachers to recognize their students' efforts during their journey of learning mathematics.

All work will be published under a Creative Commons license. If you are interested in contributing your own or (with permission) your students' work, please contact us at thevariable@smts.ca.

We look forward to hearing from you!