8 PAGE INSERT ELEMENTARY MATH

ONTARIO ASSOCIATION FOR MATHEMATICS EDUCATION

Abacus

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EQUIVALENCE AND RELATIONAL THINKING - SUBTRACTION

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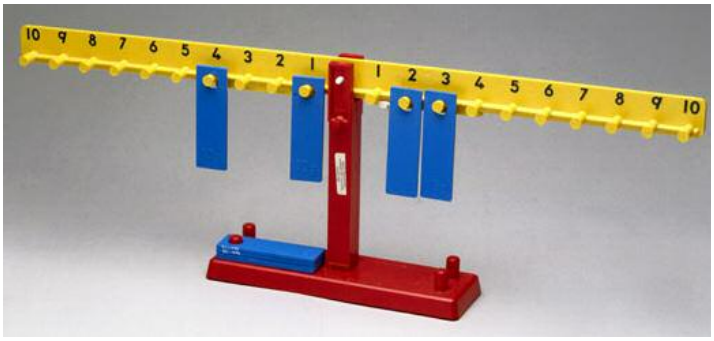


MARY LOU KESTELL works on K to 12 mathematics professional learning at the provincial level. She has spent 40+ years working in all aspects of Ontario mathematics education and is a past-president of both OAME and OMCA.



KATHY KUBOTA-ZARIVNIJ currently focuses on K to 6 mathematics professional learning at the provincial level. She is a long-time OAME board member and OAME past president. In relation to her work in mathematics education, she uses complexity thinking to interpret mathematics teaching and learning for students and teachers.

The balance metaphor is a widely used conceptual image to represent the concept, equivalence within the context addition expressions. This number line balance scale shows 4 + 1 = 2 + 3.



What would this number line balance scale look like to model:

- 4 + 1 - 2 = 2 + 3 - 2
- 4 + 1 - 2 < 2 + 3 - 1

Is it true that 8 – 3 = 8 – 4 + 1? How do you know that 17 + 21 – 21 ≠ 18 + 21 – 21?

How might the number line balance be used to model these equations?

In this issue, the Research Summary and reasoning tasks (with multiple solutions) focus on equivalence and relational thinking, within addition and subtraction contexts. The reasoning tasks in this issue are designed for use with a three-part problem-solving lesson or a Mental Math mini lesson structure. Consider including in your mathematics program planning daily learning and practice for solving subtraction true/false number sentences and open number sentences.

RESEARCH SUMMARY – EQUIVALENCE AND RELATIONAL THINKING FOR SUBTRACTION

Carpenter, Franke and Levi (2003) challenged children's conceptions about equivalence and the equal sign within number operation contexts. They asked children about how the equal sign was used. Children are justifying their thinking, convincing others as they recognize and resolve conflicting assumptions and conclusions about equality, number operations and relationships. Exploring the relationship between terms on either side of an equal symbol enables students to develop an understanding of the relationship that exists between the terms. It is important that they discover this relationship through their own thinking. These discussions require children to develop ideas and understand properties of equality inherent in number equations. An example of the Subtraction Property of Equality is about maintaining equivalence when subtracting the same quantity from both sides of the equation

Developing Relational Thinking Using Subtraction Open Number Sentences

How could you compare the expressions on either side of the equal sign to determine the value of ? 45 – 7 = - 4

a) *Operational View of the Equal Sign*

When a student does not understand that the equal sign expresses a relationship between the expressions to its left and right, the student says that:

- is 38 because 45 - 7 = 38
- is 34 because 45 - 7 - 4 = 34

- Use base ten blocks to show that the quantities on the left and right sides of the equal sign must have the same value.
- Model how to determine the value of one side of the equation and then use that value to determine the unknown quantity on the other side of the equation.

b) *Comparative View of the Equal Sign*

When a student uses a comparative view of the equal sign, the student must determine the difference between the numbers on the left side of the equal sign, in order to determine the value of and tries to determine the value of by thinking comparatively:

- Look at the numbers on both sides of the equation and make some comparisons.
- How does 5 and 2 compare? If 5 is three more than 2, then how will the value of □ compare to 39

- 45 – 7 = 38; 42 – 4 = 38; the quantities on the left and right sides of the equal sign must have the same value

c) *Relational View of the Equal Sign*

When a student uses a relational view of the equal sign, the student compares the minuend in each expression relative to the subtrahend.

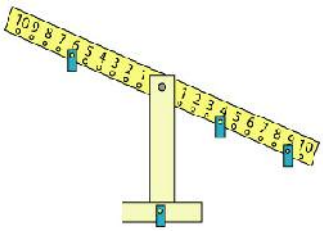
- 7 is three more than 4, so must be three less than 45

Further, Stephens (2006) investigated this subtraction equation, 90 – 59 = 99 - .

- the difference between the two numbers remains the same, if an increase of 9 in the first number (1st minuend) must be matched by an increase of 9 in the second number (2nd subtrahend)
- if the first number (1st minuend) increases to 99, then leaving the second number (1st subtrahend) as 59 changes the difference. So to keep the difference, the same the second number (2nd subtrahend) must increase by 9, giving 68
- if 90 increases to 99, then reducing the second number by nine to 50 gives an incorrect result: 90 – 59 is not equivalent to 99 – 50.

According to Stephens and Wang (2008), “a deep understanding of equivalence and compensation is at the heart of relational thinking. Students need to know the *direction* in which compensation has to be carried out in order to maintain equivalence. The direction of compensation that is appropriate for the operation of addition, for example, is inappropriate for subtraction. Some children reason incorrectly that a number sentence such as 87 – 48 is equivalent to 90 – 45. Failing to recognize that the relationship of subtraction is fundamentally different from addition, these children treat the direction of compensation for subtraction the same as for addition. Other children, however, explain, “in order for the difference to remain the same, the same number has to be added to each number in the expression”. For these children, 87 – 48 = 89 – 50.” (pp. 28-29). Furthermore, “relational thinking appears to be characterized by a capacity to see possibilities of variation between the numbers where the possibilities embody specific directions of change depending on the operations involved. Knowing that one number is greater or less than another number is no use unless one also knows the direction of change implied by these differences” (Stephens, 2006, p. 49).

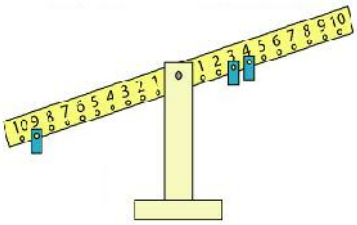
LINKS TO MANIPULATIVES: NUMBER LINE BALANCE SCALE



6 < 4 + 9

From which side of the equation does a quantity need to be subtracted to create equivalence?

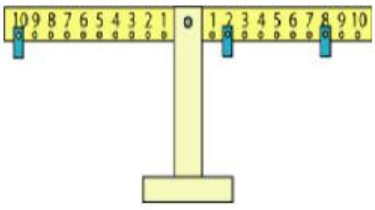
How much can be subtracted from the number line balance to create equivalence?



9 > 3 + 4

From which side of the equation does a quantity need to be subtracted to create equivalence

How much can be subtracted from the number line balance to create equivalence?



10 = 2 + 8

How much can be subtracted from each side of the number line balance to maintain equivalence?

LESSON LEARNING GOALS

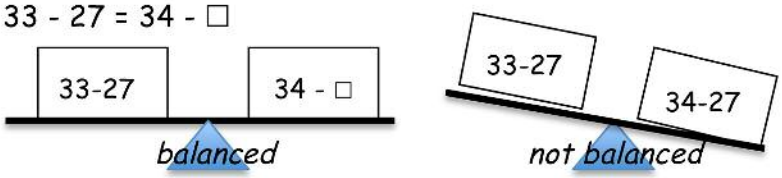
Identify the curriculum expectations (MOE, 2005) grade-before and grade-after the grade specific learning goal, in order to:
- see the development of mathematical knowledge, skills, and strategies across grade levels
- determine the mathematical focus of the problems chosen for Before (activation), During (solving problem), and After (Practice) parts of the lesson

BEFORE (Getting Started) – 5 to 10 minutes
- Activating students' mathematical knowledge and experience using a prompt or problem, related to the math in the lesson problem.
- Includes student responses to highlight ideas and strategies.

What is the Unknown Number?

What is ☐? Explain the method used.

33 - 27 = 34 - ☐



Solution 1
33-27 = 6
What number needs to be subtracted from 34 to give a difference of 6?
☐ = 28

Solution 2
(1 more) 34 > 33
☐ needs to be 1 more than 27
☐ = 28

Solution 3
33-27 = 34–28
(33+1)-(27+1)
constant difference
☐ = 28

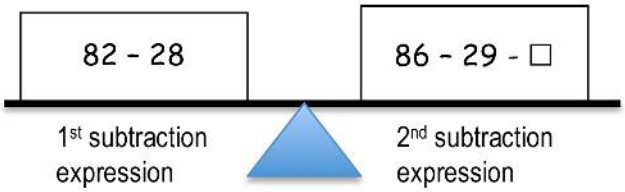
DURING (Working on It) – 15 to 20 minutes
- Understanding the problem – Teacher asks, "What information from the problem are we using to solve it? Explain." Teacher records in a list below the problem, the information that students identify.
- Students solve the problem on chart paper (landscape) with markers (visible for class discussion) in pairs or small groups.
- Teacher circulates to record different student solutions, in addition to the ones the teacher anticipated.

What is the Unknown Number?

What is ☐? Explain the method used.

82 – 28 = 86 – 29 - ☐

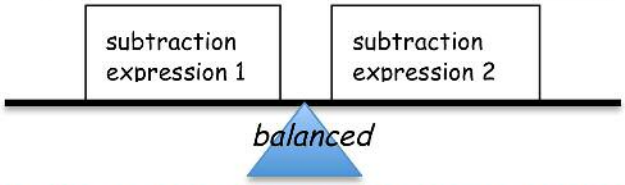
What information are we going to use to solve the problem?



☐ *means the unknown number*

` AFTER (Consolidation) – 20 to 25 minutes
- Teacher selects 2 or more solutions for class analysis and discussion in a sequence (1st, 2nd, 3rd, etc.) based on mathematical relationships between the solutions and the lesson learning goal.
- Students (authors) explain and discuss their solutions with their classmates; co-construction of success criteria towards the lesson learning goal
- During whole class discussion, solutions are organized (often re-organized) to show mathematical elaboration from one solution to the next and towards lesson learning goal.
- Teacher mathematically annotates (math terms, math symbols, labelled diagrams, concise explanations) on and around solutions to make mathematical ideas, strategies, and models of representation explicit.

*Visualize the quantity for each number expression so there is balance (**equivalence**)*



***Same Difference** – the result of subtracting numbers in the first expression is the same quantity as the result of subtracting numbers in the 2nd expression*

Solution 1
Subtract numbers in the 1st expression to get difference
82–28 = 82–20–2–6
82–28 = 62 – 2 – 6
82–28 = 54 (difference)

Subtract 2 numbers in the 2nd expression, then subtract to get same difference as 1st expression
54 = 86–29– ☐
54 = 86–26-3 – ☐
(decompose 29 into 26 and 3)
54 = 60–3 – ☐ ; 57-54=3
54 = 57–☐ ☐=3

Solution 2
Subtract numbers in the 1st expression to get difference
82–28 = (82+2) – (28+2)
84 – 30 = 54 (difference)

Get same difference; so subtract the difference in the 1st expression from the difference of 2nd expression
☐ = 86-29 - 54
☐ = (86+1)-(29+1)-54
(easier to subtract tens- +1 to each term -keep the difference constant)
☐ = (87-30) – 54 = 3
57 – 54 = 3 so ☐=3

Operational
Difference from 1st Subtraction Expression Used for 2nd Expression

Operational
Subtract Same Difference from 2nd Subtraction Expression to get ☐

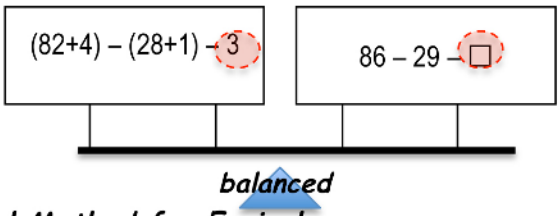
Note: Mathematical *annotations* include mathematical vocabulary, symbols, elaborations of mathematical details from solutions, labels describing the method/strategy and questions to further thinking. All *annotations* are records of students' mathematical discussion.

Grade 2	Grade 3	Grade 4
determine the missing number in equations involving addition and subtraction to 18	determine, the missing number in equations involving addition and subtraction of one- and two- digit numbers	determine the missing number in equations involving multiplication of one- and two-digit numbers

Equivalence or Equality

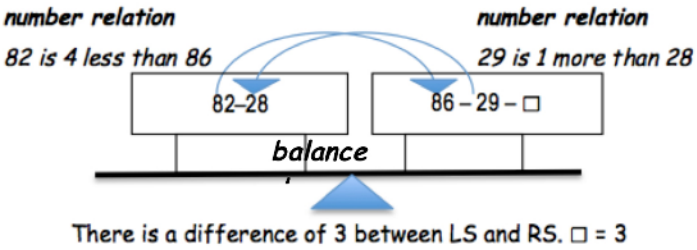
An equation indicating that two quantities (or expressions) are in balance; two expressions that are equivalent (e.g., 82 – 28 = 86 – 29 - ☐*).*

Compensating Method for Equivalence



Relational Method for Equivalence

Comparing pairs of numbers from expression 1 and 2.



There is a difference of 3 between LS and RS. ☐ = 3

AFTER (Highlights/Summary) – 5 minutes

- Teacher and students revisit the student solutions for key ideas, strategies, and models of representation that are related to the lesson learning goal (anticipated success criteria)
- Teacher lists key ideas, strategies, and models of representation so the students can see how the mathematical details from their solutions relate explicitly to the lesson learning goal; summary of co-constructed success criteria

Highlights/Summary

Determine unknown number in subtraction equations using different methods:

- ***operational*** *– calculating the operations for both number expressions (e.g., 82-28 = 82-20-2-6 = 54)*
- ***compensating*** *– making pairs of numbers the same by adding or subtracting numbers (e.g., (82+4)-(28+1) = 86-29 -3*
- ***relational*** *– comparing pairs of numbers in expressions to know the number relations (e.g., 82<86 (LS 4 more); 28<29 (RS 1 more)*

AFTER (Practice) – 5 to 10 minutes

- Teacher chooses 2 or 3 problems, similar to the lesson problem for student to solve in pairs as a scaffold and individually.
- Problems could vary by number (choice, size), problem contexts, or what is unknown or needs to be solved
- Students are asked to solve these problems using a strategy different from the one they used for the lesson problem.

What is the Unknown Number?

What is ☐? Explain the method used.

74 - 37 = 71 – 39 + ☐

Solution 3

82–28 = 86-29– ☐

Make pairs of numbers the same to know the unknown

82-28 = (82+4)-(29-1)- ☐

☐ = 4-1

= 86–29 – 3

☐=3

Solution 4

82–28 = 86-29– ☐

Comparing pairs of numbers from each expression

82 < 86 (4 more)

28 < 29 (1 more)

balance →4 more (left side) minus 1 more (right side)

☐=3

Compensating

Make Terms Same to See the Unknown

Relational

Compare Pairs of Terms Across 2 Expressions

Solution 1

74 - 37 = 71 - 39 + ☐

Relational Comparison

(3 more) 74 > 71

37 < 39 (2 more)

Balance each side - Make equivalent 2 expressions

3 more LS; 2 more RS

So ☐=5

Solution 2

74 - 37 = 71 - 39 + ☐

Compensating

74-37

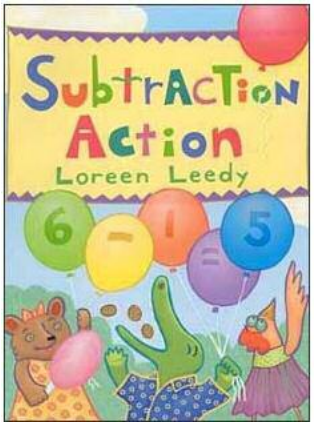
= (74-3)-(37+2)+5

= 71 – 39 + ☐

So ☐=5

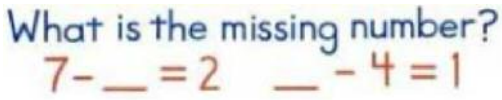
Note: A classroom board is longer proportionally than these 2 pages. Due to the space constraints on these pages, the mathematical *annotations* are recorded above the solutions with arrows, rather than on and around the solutions.

LINKS TO LITERATURE: SUBTRACTION ACTION



This non-fiction picture book, *Subtraction Action* by Loreen Leedy includes different representations of subtraction. Miss Prime and her students spend a day at the school fair and use subtraction in many ways. The class watches a puppet play in which cookies disappear from Little Red Riding Hood's basket. Another situation involves price slashing at two competing refreshment stands. Mathematical details include the definition of difference, writing a subtraction equation, regrouping, and three-digit equations. Tally and Otto use subtraction to sell snacks and Fay tries to break an obstacle-course record. A math problem is presented in every episode with the answers given on the back page.

Elaborate on the subtraction contexts by emphasizing equality of two subtraction expressions, with unknown subtrahend or minuends.

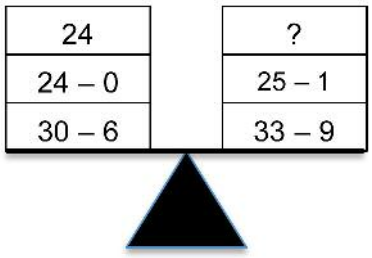


LET'S DO MATH – TRUE/FALSE NUMBER SENTENCES

Before (Getting Started)

What numbers could be subtracted to make a difference of 24?

- Record student responses on a drawn balance scale.
- Possible responses -> 24 – 0, 25 – 1, 26 – 2, and so on.
- Ask, "What subtraction expressions could be put on the other side to create a balance?"



During (Working On It)

Subtraction True/False Number Sentences:

True or False? 135 – 49 = 145 – 59

After (Consolidation)

Anticipating Student Responses:

Solution 1

135 – 49 = 145 – 59

L.S. = (135 + 10 – (49 + 10)
= (145) – (50 + 10 – 1)
= 145 – 59

True – compensation I took away more than I needed to and then added some back. I also used the common difference principle.

Solution 2

135 – 49
= 135 – 30 – 10 – 9
= 105 – 10 – 9
= 86

145 – 59
= 145 – 40 – 10 – 9
= 105 – 10 – 9
= 86

True – both expressions have a difference of 86.

Solution 3

Left side Right side

135 < 145 (+10)
49 < 59 (+10)

Differences between the minuend and subtrahend are the same.

135 – 49 = 145 – 59

True –constant difference. If I add a number to the minuend and the same number to the subtrahend, then I will have

the same difference as when I started.

Coordinating Discussion for Student Learning:

Why might solution 3 be chosen first for student discussion followed by solution 1, and 2?

- *Solution 3* – relational – constant difference – same number added to each of the terms in the subtraction question results in the same difference
- *Solution 2* – operational -> calculated each expression and compared the differences
- *Solution 1* – compensating -> I took away more than I needed and added some back. I also used common difference: when subtracting, if I add a number to the minuend and the same number to the subtrahend, then I get the same difference

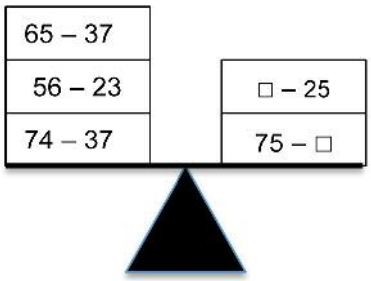
LET'S DO MATH – MENTAL MATH OPEN NUMBER SENTENCES

Before (Getting Started)

What is the value of □ ? Explain your method.

Record student responses on a drawn balance scale.

- Operational – subtract the terms in the 1st subtraction expression and use that difference to subtract the term from the 2nd expression to get value of □
- Compensating – adjust value of terms in the 1st subtraction expression to be similar to terms in the 2nd subtraction expression
- Relational – Compare pairs of terms from each subtraction expression to determine how much greater one term is from another term



During (Working On It)

Subtraction Open Number Sentences

What's the value of □ ? 74 – 37 = 71 – 39 + □

After (Consolidation)

Anticipating Student Responses:

Solution 1

74 – 37 = 71 – 39 + □

(74 – 3) – (37 + 2) + □= 71 – 39 + □

74 – 3 – 37 – 2 + □ = 71 – 39 + 5

Solution 2

74 > 71 Minuend 3 less
37 < 39 Subtrahend 2 more

So difference □ = 5

Solution 3

L.S. 74 – 37	R.S. 71 – 39 + □
= 74 – 30 – 4 – 3	= 71 – 40 + 1 + □
= 44 – 4 – 3	= 31 + 1 + □
= 37	= 32 + □ = 37
	□ = 5

Coordinating Discussion for Student Learning:

Why might solution 3 be chosen first for student discussion, followed by solution 1 and 2?

- *Solution 3* - operational – subtracted the terms in the 1st subtraction expression and subtracted the terms in the 2nd subtraction expression to get value of □
- *Solution 1* - compensating – adjust value of terms in the 1st subtraction expression to be similar to terms in the 2nd subtraction expression
- *Solution 2* - relational – compare pairs of terms from each subtraction expression to determine how much greater side of the equation is from the other

NEXT STEPS FOR YOUR PROFESSIONAL LEARNING

Application to Your Classroom

- Consider how equivalence, reasoning tasks (e.g., True/False Equations, Open Number Sentences) develop students' understanding of number relationships and the use of different strategies for addition, subtraction and relational thinking.
- To suit your students' learning needs, select and design reasoning tasks that are relative to grade specific curriculum expectations in the Patterning and Algebra strand (equivalence) and the Number Sense and Numeration strand (addition and subtraction of 1 digit, 2 digit and 3 digit numbers; mental math addition and subtraction), being mindful of the transition from calculating and comparing the results of addition and subtraction expressions towards analyzing number relationships between addends, minuends and subtrahends when determining the equivalence of addition expressions.
- Incorporate daily practice of addition and subtraction strategies and relational thinking practices through daily mental math mini lessons, two times a day.
- Practise noticing the different methods and the breadth of the mathematics your students use to solve equivalence reasoning tasks, such as, carrying out the operations for each expression, comparing terms in the addition and subtraction expressions, adjusting the terms to make them similar in order to see the difference or unknown (compensating).
- Think ahead of the kinds of mathematical annotations you will record on and around the student solutions to make explicit addition and relational thinking strategies for solving equivalence reasoning tasks.

Suggested Readings

Some readings used in the Research Summary and in the development of the problems and solutions are listed below.

- Carpenter, T., Franke, M., & Levi, L. (2003). *Thinking mathematically: Integrating arithmetic & algebra in elementary school.* Portsmouth: Heinemann.
- Carpenter, T., Levi, L, Franke, M., and Zeringue,J. (2005). Algebra in elementary school: Developing relational thinking. *ZDM, 37*(1), pp. 53-59.
- Molina, M., Castro, E., and Mason, J. (2008). Elementary school students' approaches to solve true/false number sentences. *PNA* 2(2), pp. 75-86.
- Stephens, M. (2006). Describing and exploring the power of relational thinking. Conference Publication at **http://www.researchgate.net/publication/236661303**, pp. 479-486.
- Stephens, M. & Wang, X. (2008). Investigating some junctures in relational thinking: A study of Year 6 and Year 7 students from Australia and China. Journal of Mathematics Education, 1(1), 28-39.

CLOSING

Our next issue will focus on Equivalence and Relational Thinking within multiplication contexts. As well, the ways that teachers can use these mathematical ideas and pedagogical strategies within learning and teaching mathematics within a three-part problem solving lesson framework are outlined.

CALL FOR *ABACUS* SUBMISSIONS

Send your teaching strategy ideas, problems and student solutions to the *Abacus* Co-Editors via email

	CONFERENCE DELEGATES (includes 1 year Digital OAME Membership)			RETIRED OAME MEMBERS	STUDENT DELEGATES
	Early Bird Fee *due by Feb 29*	Conference Fee *paid by April 15th*	Conference Fee *paid on-site (space permitting)*	Fee	Fee
Full Conference	330	355	375	280	210
Thursday only	205	230	240	160	100
Friday only	225	250	260	160	100
Saturday only	145	155	170	120	75
Thursday & Saturday	275	300	310	240	160
Friday & Saturday	295	320	325	240	160

REGISTRATION

PRE-REGISTRATION
NOVEMBER 15TH, 2015- JANUARY 19TH, 2016
• Delegates may select the day(s) that they will attend the conference; sessions not available for booking

FULL REGISTRATION
OPENS FEBRUARY 1, 2016
• Early Bird Deadline – payment in full by February 29, 2016

REGISTRATION CLOSES
APRIL 1,2016

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GEORGIAN COLLEGE, BARRIE

INFO BARRIE

DINING IN BARRIE

The Barrie Tourism website contains detailed information as well as coupons and great deals for dining in the Barrie area.

http://www.tourismbarrie.com /where_to_eat.aspx

ACCOMMODATIONS

Choose from an excellent variety of top notch accommodations to suit your style. Barrie offers many choices in quality and comfortable accommodations.

http://www.tourismbarrie.com /where_to_sleep.aspx

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ONTARIO ASSOCIATION FOR MATHEMATICS EDUCATION

KEYNOTE SPEAKERS

DR. STEVEN STROGATZ



The Joy of X

Hailed as "a gifted and inspiring communicator" and "a first-rate storyteller and an even better teacher," Strogatz shows how synchrony occurs spontaneously in nature, from atoms to solar systems – almost as if the universe had an overwhelming desire for order. He answers the questions that we find ourselves asking over and over: Why do traffic jams seem to occur without any apparent cause? How do millions of neurons fire together to control our breathing? How can a movie theater full of strangers begin to applaud in rhythm? And are we really all separated from one another by just six degrees – even from Kevin Bacon?

DR. SARAH J. GREENWALD



Good News Everyone! Mathematical Morsels from The Simpsons + Futurama

Sarah J. Greenwald is Professor of Mathematics at Appalachian State University. Join us as Dr. Greenwald uncovers humorous mathematical references in popular television shows such as The Simpsons and shares her belief that popular culture can reveal, reflect, and even shape how society views mathematics.

DR. ROBERT LANG

From Flapping Birds to Space Telescopes: The Art and Science of Origami



Robert Lang merges mathematics with aesthetics to fold elegant modern origami. His creations inspire awe by sheer force of their intricacy. As a bonus you can learn origami from one of the world's leading masters of the art at the OAME banquet. "Lang creates creatures of such complexity that it seems impossible that each is composed of a single sheet of paper, no cuts, no glue." — Apple.com

FEATURED SPEAKERS

- **RUTH BEATTY** *"Indigenous and Western Ways of Knowing Mathematics: Continuing to Build Connections"*
- **LISA LUNNEY BORDEN** *"Honouring Indigenous Knowledge in the Mathematics Classroom: A Learning Together Approach"*
- **CATHY BRUCE** *"Fractions Teaching and Learning: What's the big deal?"*
- **DON FRASER** *"Taking the Numb out of Numbers"*
- **JILL GOUGH** *"Deep Practice: Building Conceptual Understanding in Middle Grades"*
- **NICHOLAS JACKIW** *"Time's Arrow: Where School Geometry Comes From and Where It's Going"*
- **RON LANCASTER "***I'm Thinking of a Number: Introducing Your Students to Micah Lexier, an Artist who uses Mathematics and Measurement to Visualize Information and Data"*
- **ALEX LAWSON** *"Why Just Knowing the 'Facts' Is Not Enough: The Mathematical Territory Between Direct Modeling and Numerical Proficiency at the Primary Level"*
- **JOAN MOSS** *"Expanding Horizons in K-3 Geometry and Spatial Thinking: New Approaches to Support all Learners"*
- **CONNIE QUADRINI** *"Supporting Students with Learning Disabilities in Mathematics"*
- **NATHALIE SINCLAIR** *"Moving Geometry in the K-4 Classroom: More than just vocabulary"*
- **MARIAN SMALL** *"Picture It!!"*
- **CHRIS SUURTAMM** *"Developing Algebraic Thinking"*

There is something for everyone at OAME 2016. Choose from a wide variety of sessions. For more details on the program, speakers, and schedule please visit www.oame2016.ca

WOULD YOU LOVE TO COME TO OAME 2016 BUT ARE UNABLE TO DUE TO GEOGRAPHY OR SCHEDULE?

CONSIDER ATTENDING THE OAME ECONFERENCE

Choose from:
- Full Day Thursday
- Full Day Friday
- Both Days
- Selected individual sessions

The eConference will include a variety of live streaming sessions, pre-recorded sessions, and interaction with presenters through social media.

Join colleagues across the province in learning from Marian Small, Alex Lawson, Cathy Bruce and more.

Registration opens on February 1st.

SOCIAL EVENTS

For more details of social events including: times, ticket info or to sign up visit *www.oame2016.ca*

Math Mystery Tour
Wednesday May 4, 2016

OAME BANQUET
Barrie Golf and Country Club
Thursday May 5, 6:30 pm

Celebrating Math Educators and Past OAME presidents. In a hands on presentation, special guest speaker Dr. Robert Lang will guide the audience in practicing the art of origami.

Flying Monkey Brewery Tour
Thursday May 5
Dinner at 5:00 pm • Tour at 7:00 pm

KenKen Tournament
Friday May 6, 2016

Casino Rama, Orillia
Friday May 6, 5:30

Rock Wall Climbing @ Gerogian College
Friday May 6, Time TBD
+
Georgian College Fitness Centre Access

Wine and Cheese
Thursday May 5, 4:00 PM – 5:30 PM
Exhibitor's Area