Math Content Knowledge Test for Teachers

Table Discussion 1: Let's talk about the candidates...

Who should be required to write the test?

There was significant discussion regarding elementary vs. secondary teachers. Consideration needs to be given to the secondary subject specific specialization factor. Not understanding the actual content of the proposed testing there are teachers who already possess degrees specializing in mathematics or have been successful at university level/college mathematics courses which reflect content knowledge. If the test is solely about the knowledge then exemptions should be considered for these individuals. However, if the test involves math knowledge for teaching and pedagogy then exemptions would not apply and in that case it would apply as follows:

> All teacher candidates in Faculties of Education in Ontario prior to being issued Ontario College of Teachers (OCT) certification. This would include any teachers coming from other jurisdictions outside of Ontario prior to being issued OCT certification.

What might be considered an "equivalent"?

See answer above.

Note: A degree in mathematics, science or engineering does not constitute having knowledge that is unique to the teaching and learning of mathematics.

What are the benefits or drawbacks of having 'equivalents'?

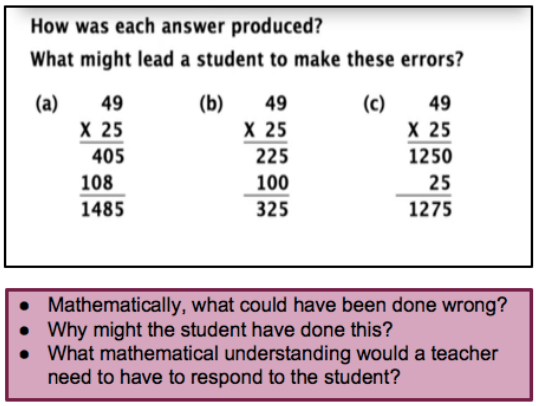
One of the benefits could be cost savings. However, a degree in mathematics or engineering does not constitute having knowledge that is unique to the teaching and learning of mathematics.

Table Discussion 2 Let's talk about content and format...

What would be the best format for the test (multiple choice, short answer)? Why?

Both multiple choice and short answer. For example, multiple choice would not address the questions noted in the pink box below. Knowing how to multiply using a standard rule and recognizing that an answer is incorrect is not sufficient. A teacher needs to be

able to observe and make interpretations about the student's understanding.



Short answers would better reflect the classroom experience and expectations that we have for our students to reflect deeper conceptual thinking and understanding.

Although it is understood that faculties of education are evaluating students on their ability to apply pedagogy during their teacher education program and practicum components, they should also be tested in their application of pedagogy to the teaching of mathematics.

Questions arose regarding whether the knowledge/content should be tested by division. However this may limit teacher mobility and flexibility of teacher assignments by school boards. Every effort must be made to ensure that these tests do not discourage people from applying to the teaching profession.

What should be tested? What can it reveal?

Beyond strictly math content:

- knowledge of how students learn mathematics developmentally (e.g., students will think additively before thinking multiplicatively)
- knowledge of the principles of math (e.g., commutative property, associative property)
- knowledge of different strategies (e.g., area model for multiplication, repeated addition, decomposing numbers to multiply)
- knowledge of how various strategies connect knowledge of pedagogy to support the teaching and learning of mathematics (e.g., instruction and assessment strategies)

It will reveal whether or not the teacher has knowledge of identifying student thinking, interpreting student thinking, confirming student thinking, and then planning next steps.

Consideration and further discussion is required regarding the candidate's division level. (see answer above)

How rigorous should the test be?

Challenging enough to address the knowledge teachers need to have to create meaningful learning experiences for all students.

Does the level of teacher qualification change the level of rigour?

Yes - elementary vs. secondary.

Any thoughts about those currently teaching?

The test should be implemented at the faculty of education level for teacher candidates in Ontario. For those already teaching, the Ministry should expand funding so that school boards can continue to provide professional learning opportunities, math coaches, subsidize math AQ courses, and provide access to applicable resources.

Table Discussion 3 Let's talk about access...

How do we make the test equitable and accessible?

It should be accessible to all and written at the faculty of education prior to graduation and certification. If it is written within the first of the two-year teacher education program, then there will be time to do additional courses and/or remediation for any teacher candidate that is unsuccessful. For any teacher coming from outside of Ontario the test would be facilitated by the OCT. Allow for accommodations and modifications, as needed.

How do we support candidates so that they are prepared to write the test?

See answer above.

Faculty staff should be excellent in their teaching of the post-secondary pedagogical content. Provide access to Faculty of Education math content courses, on-line modules or tutoring. Practice tests could be created and hosted online.

How many attempts to write should be considered?

Three times.

How might candidates receive support if they don't pass the test?

Many Faculties of Education already offer a mandatory or optional math content

course. If the test is taken within the first year there could be ample opportunity for learning and improvement through supplemental course work, tutoring, on-line modules, etc.

Table Discussion 4 Let's talk about other considerations...

Do you have any thoughts about math content knowledge testing vs. math knowledge for teaching?

Math content knowledge differs significantly from math knowledge for teaching. Specifically, teachers who know mathematics for teaching have knowledge of or the ability to do the following (adapted from Ball & Thames, 2010):

- Understand how students learn mathematics development;
- Use and choose strategies and model students thinking and learning;
- Build students trust and self-efficacy;
- Pose meaningful mathematics questions;
- Give and appraise explanations;
- Select or design tasks;
- Use and choose multiple representations;
- Note students' mathematical thinking;
- Analyze student errors;
- Address possible misconceptions;
- Facilitate mathematical discourse;
- Define terms mathematically;
- Know when a student's answers are incorrect (i.e. mathematically, what could have been done wrong), know why a student might have made the error, and have the mathematical understanding needed to respond to the student.
- Demonstrate how to carry out a procedure or algorithm; and
- Use appropriate mathematical language.

Have you done any research or jurisdictional scans that might help inform our efforts?

N/A

What other research are you aware of that might help inform our decision-making?

Anthony and Walshaw (2009) identify ten principles that underpin effective pedagogical practices to support student learning in mathematics:

(1) An ethic of care;
(2) Arranging for learning;
(3) Building on students' thinking;

(4) Worthwhile mathematics tasks;
(5) Making connections;
(6) assessment for learning;
(7) Mathematical communication;
(8) Mathematical language;
(9) Tools and representations; and
(10) Teacher knowledge.

McDougall (2004) identifies ten interdisciplinary dimensions of mathematics education to support change in mathematics education. The Ten Dimensions of Mathematics Education provide a conceptual framework for strengthening and shifting the teaching and learning of mathematics (McDougall, 2004).

(1) program scope and planning;
(2) meeting Individual needs;
(3) learning environment;
(4) student tasks;
(5) constructing knowledge;
(6) communicating with parents;
(7) manipulatives and technology;
(8) students' mathematical communication;
(9) assessment; and
(10) teacher knowledge and comfort with mathematics.

The National Council of Teachers of Mathematics (NCTM, 2014) developed a research-informed framework identifying Eight Mathematical Teaching Practices to enhance the teaching and learning of mathematics. Those with high-leverage teaching practices represent a core set practice and essential teaching skills necessary to promote deep learning of mathematics.

1) Establish mathematical goals to focus learning.
2) Implement tasks that promote reasoning and problem solving.
3) Use and connect mathematical representations.
4) Facilitate meaningful mathematical discourse.
5) Pose purposeful questions.
6) Build procedural fluency from conceptual understanding.
7) Support productive struggle in learning mathematics.
8) Elicit and use evidence of student thinking.

Hattie, Fisher & Frey (2017) extend Hattie's original meta-analysis of educational practices in *Visible Learning* (2009) to specifically address teaching practices specific to mathematics. The practices are intended to help teachers design high-impact instruction to enhance student learning.

1) Make learning visible by balancing surface, deep, and transfer learning.
2) Make learning visible through teacher clarity. (i.e. clarity of organizations, explanation, instruction, and assessment that is seen by students)
3) Make learning visible through appropriate mathematical tasks and mathematical talk.

4) Assess learning and provide feedback.

Adapted from Deborah Ball

The intent is to support teaching and learning of mathematics by providing teachers with different types of knowledge:

- knowledge of pedagogy (effective practices to support the teaching and learning of mathematics);
- knowledge of who their learners are;
- knowledge that is specific to the teaching and learning of mathematics so that we can elicit, gather evidence of thinking and learning, interpret the evidence, confirm the evidence of thinking and learning, and provide next steps.

Please share any other ideas/thoughts regarding the Math Content Knowledge Test.

A test solely based on content knowledge will likely not yield the intended results linked to student outcomes. This has been shown to be the case in other jurisdictions that have implemented such a test, including Australia, England, and New York state. Of particular note is that Ontario has consistently surpassed those jurisdictions on international tests such as PISA. There is more support for an emphasis to be placed at the Faculty of Education level on both content knowledge and pedagogy, and in school boards on a continuum of on-going professional development opportunities, coaching models in schools, subsidies for Additional Qualification courses and the continuation of the New Teacher Induction Program.

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1. What are the strengths and challenges of the Ontario Curriculum: Mathematics, Grades 1 to 8 (2005)?

Strengths	Challenges
- "A cool curriculum" (Alan Luke). A "hot" curriculum is very prescribed and tells teachers what to do with a few degrees of freedom. A "cool" curriculum gives teachers the opportunity to imagine and construct based on learners' need. *Allan Luke (2012) states,"The Ontario curriculum by international standards is a 'cool' curriculum. The Ontario curriculum provides guidance, but does not overprescribe. A 'cool' curriculum gives teachers a common vocabulary so they can talk about teaching practice, instead of telling teachers to teach."* - Addresses overall expectations and supporting specific expectations - Reference to mathematical thinking through the processes - Glossary of terms - Achievement chart addresses the importance of students knowing and understanding, communicating their mathematical understanding of concepts, applying their understanding, and teaching through problem solving to supports students conceptual understanding of mathematical concepts and skills) - Within the achievement chart, the categories, criteria, descriptors and qualifiers set parameters, but also allow the teacher to use professional judgment, making it possible to differentiate assessment based on students' needs	- Specific expectations should explicitly address mathematical thinking and mathematical knowledge and skills - Lack of explicit connections between the mathematical process expectations and content expectations (overall and specifics) - Does not address the 'big ideas' in math, which are mathematical statements that link concepts and skills into a coherent whole. For example, decomposing whole numbers and recomposing them are critical skills for representing, comparing, and operating with numbers. (Small, 2017) - Does not address how to build procedural fluency from conceptual understanding - Does not address the notion of Numeracy. Tthe Language Curriculum explicitly addresses Literacy - Does not make explicit connections to the 6 C's, well-being or competencies such as character, citizenship, collaboration, communication, creativity, critical thinking (Fullan) - Does not explicitly address financial literacy - Most concepts follow research along a developmental continuum, which is not always explicit. - The content is too much to cover and can be overwhelming becoming a checklist. Nothing is prioritized – all strands/expectations are of equal

- Encourages the use of thinking tools so that students can build a conceptual understanding of mathematics concepts - Implicitly aligns to a mathematical learning progression throughout the grades (i.e., what we know about how students learn mathematics developmentally - Emphasis on the use of visual math models and manipulatives to support conceptual understanding	value, there is no weight or value leading to inconsistencies amongst teachers in the delivery of the curriculum - Insufficient support about what the thinking processes look like - some models are more powerful than others - The evaluation and reporting by strands - being strand-based can allow aspects of the curriculum to be taught and reported on in isolation, e.g. number sense is connected and embedded in all strands - Examples should be updated using student interest and an equity lens - Models used to develop mathematical ideas could be more detailed for each grade - Split grades are not addressed

2. **What curriculum features, content, resources are necessary to better support educators in teaching mathematics?**

A revised curriculum document that is based on a more simplified developmental trajectory through the grades and identifies big ideas as well as curriculum competencies (i.e., what students are doing, what are our process expectations?) and very specific content around what students are to know. (e.g., in Grade 7 students are expected to know circle graphs) Connections between the grades could be more clearly detailed for teachers.

There needs to be a teacher companion guide to a revised curriculum document that is:

- explicit in the order in which the skills are taught and assessed;
- includes diagnostic assessments so that educators can determine gaps in the learning;
- identifies explicit instructional strategies/methodologies along with “look fors” for educators so they can name what it is students are being asked to do;
- include tools for learning (concrete materials, online resources, apps); and
- a standards based assessment tool (similar to DRA in reading) so that educators can determine math levels in all grades

Specifically:

- Examples of learning goals and success criteria to support assessment
- Examples of learning experiences that highlight learning goals, success criteria, math tasks, the use of effective questions to elicit further thinking, examples of student response, evidence of learning, and feedback
- Links to resources that would support teachers (and provide opportunities for them to build an understanding of the mathematics they would need to engage students in the learning experiences) specifically referring to the notion of professional learning
- Explicit connections to competencies required to support our modern learners
- Resources to help teachers understand the difference between assessment *for/as* and assessment *of*
- Explicitly address how to triangulate evidence of learning
- Explicit links to how thinking tools (e.g., manipulatives) can be used to enhance learning
- Resources to help teachers better understand their learners, referring to strength, needs, interests, and learning styles (referring to helping teachers develop learner profiles)
- Supports that help teachers makes sense of mathematical thinking so they can elicit thinking and identify evidence of student thinking, for example, what constitutes refection, what questions could be posed to elicit reflection
- Resources to help a teacher foster learning environments that support teaching and learning, student engagement and positive mindsets towards mathematics
- Purposeful use of technology (e.g., web-based applications offering virtual learning environments)
- Links to computational thinking (e.g, opportunities for algorithmic thinking, coding, and programming)
- Teaching through inquiry (e.g, reflecting on thinking, exploring to make sense of concepts, and opportunities to pose wonderings)
- Examples of learning experiences that provide opportunities for knowledge construction through explorations, investigation, discovery and creation
- Supports for home
- Mathematical process expectations could become a strand on their own, as in other curriculum documents
- Expand and continue access to *A Guide to Effective Instruction in Mathematics*, *Paying Attention to* series, research monographs digitally and in print form and online professional learning resources to encourage job-embedded professional learning that includes opportunities to monitor student work, discuss next steps for improvement and monitor the effectiveness of strategies implemented
- Updated resources from publishers and Ministry of Education funding to purchase resources and to have access to math instructional coaches in every school.

3. **What would you like to see outside of changes to the curriculum to keep math as an area of focus in the province?**

- Review and share approaches across Faculties of Education related to mathematics/pedagogy for greater consistency in assessing and supporting teacher candidates in the area of content knowledge and pedagogy including Additional Qualification courses.
- Increased collaboration between the Ministry of Education, Faculties of Education and school districts to help teachers develop the subject matter knowledge (common, horizon and specialized content knowledge) and pedagogical content knowledge (knowledge of content and students, content and teaching, content and curriculum) needed for effective math instruction in diverse classrooms across Ontario, including the development of AQ courses for teachers and administrators.
- Support for school administrators in developing a culture of literacy and numeracy in schools
- Incorporate effective practices to support the teaching and learning of math (incorporate the research outlined below from the National Council of Teachers of Mathematics and/or Anthony and Walshaw and/or Douglas McDougall and/or Hattie)

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- Mathematical ways of being (reference to attitudes and beliefs about mathematics)
- A focus on the mental actions of mathematical thinking (i.e., analyzing, making inferences, interpreting, synthesizing, reflection, reasoning, and evaluating) to make sense of mathematics concepts and skills
- How can we structure the curriculum so that assessment isn't seen as being separate from instruction?
- Similar to literacy (four roles of the literate learner), there should be a focus on numeracy (four roles of the numerate learner)
- Better understanding of how students learn mathematics developmentally
- Making sense of mathematical thinking

Mathematical Thinking	
Actions	**Outcome**
• Inferring and interpreting • Analyzing • Evaluating • Reflecting • Looking for patterns • Making connections • Making conjectures • Recognizing relationships • Identifying and incorporating appropriate mathematical knowledge and skills needed to solve a problem • Representing • Reasoning	• Making generalizations • Seeing mathematics as a connected whole as opposed to isolated concepts and skills • Justifying with evidence • Drawing conclusions • Applying knowledge and understanding of mathematical concepts and skills • Reflective learner • Synthesizing • Sense of mathematical concepts and skills

- Targeted mathematics intervention program like we have for reading to help close the gaps in learning
- Connections between math and other subjects so that math is not seen as being isolated (e.g. using math vocabulary in other subject areas)
- Any changes in the math curriculum need to be reflected within growing success and report cards as appropriate

Additional Thoughts…

- The intent is to support teaching and learning of mathematics by providing teachers with different types of knowledge:
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    - Knowledge that is specific to the teaching and learning of mathematics so that we can elicit, gather evidence of thinking and learning, interpret the evidence, confirm the evidence of thinking and learning, and provide next steps.

    (Adapted from Deborah Ball)

- Our attitudes and beliefs about the teaching and learning of mathematics, and our sense of efficacy is an integral component.