Webcasts for Educators
Student Achievement Division

Viewer's Guide

Planning for Mathematical Understanding: Fractions Across the Junior Grades

Multi-media resource for professional learning

support every child
reach every student

Ontario

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On this DVD you will find a Print and Video Resources folder which contains WMV files, this Viewer's Guide (PDF) and Additional Resources such as tips, links and sample problems.

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Overview

This webcast follows a group of junior teachers in Wellington Catholic District School Board who as a division plan, implement and reflect on a unit on exploring fractions. As teachers collaboratively experience this process, they learn how to "teach through problem solving." They also gain a better personal understanding of fraction concepts and how they develop from grade to grade. As well, they become more responsive to student learning as they explore ways to adapt the unit to meet student needs.

The segments in this webcast are presented in three sections:

Collaborative Unit Planning – This section identifies the critical components for effective divisional planning of a unit.

Emerging Learning Around Fraction Big Ideas – This section highlights the big ideas about fractions that emerge as students engage in the math and as teachers learn from interacting with their students and with each other.

Debrief and Reflection – In this section, educators and students reflect on the unit and what they have learned from this process.

Why are fractions so important?

Fractions are a complex concept to both teach and to learn. As a result, educators may often revert to rules and tricks rather than working with students to attain deep conceptual knowledge.

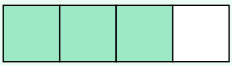
Consider the following quote …

> Elementary school students' knowledge of fractions and of division uniquely predicts those students' knowledge of algebra and overall mathematics achievement in high school.
>
> Siegler, 2012

Reflect on your own learning experiences about fractions. What do you remember?

From Viewing to Action

Before beginning the webcast, you may wish to fill out the *Anticipation Guide about Fractions*. When you have finished the video, it might be interesting to reflect back on these ideas. You can also view the completed Anticipation Guide answer sheet in the Print and Video Resources section of this resource.

Idea	Agree	Disagree	Not Sure
The parts of a whole (e.g. a rectangle) must be equal in size and shape.			
Fractions always represent amounts less than one.			
The closer together the numerator and denominator are, the larger the fraction.			
If two fractions have the same numerator, the one with the greater denominator is greater.			
There are an infinite number of fractions between any two fractions.			
$1/8$ can never be larger than $1/2$.			
Whole numbers can be represented as fractions.			
When representing sets as fractions, all items in the set must be identical.			
A fraction always gets bigger if the numerator and denominator are increased.			
The following picture can only represent three fourths. 			

Problems, Links and Tips

Throughout the webcast, math problems are investigated by the students and later discussed among their teachers. You may wish to solve these problems yourself, to consolidate your own understanding and to anticipate the student thinking that emerges in the video. You can find these problems, along with other tips and links in the Print and Video Resources section. To access this section on the DVD, please right click the DVD icon in your "My Computer" folder.

Samples:

- **Mindmaps** can be effective for having students explore how fractions are used in our daily lives. For more ideas about using mindmaps, refer to Dr. Cathy Marks Krpan's book *Math Expressions: Developing Student Thinking and Problem Solving through Communication*, pages 120 to 124.
- **Fraction Introductions**
  Have students describe something about themselves using a fraction. (I make up 1/5 of my family, I am ¾ through the month of February, I have read ½ of my book). Discuss which scenarios let you know how much the part and the whole represent, and which are ambiguous.
- **The Cake Dilemma**
  For Danielle's birthday, her dad ate one fifth of the cake, her brother ate 2/10 of the cake, Danielle ate 3/10 of the cake and her mom ate one piece. What fraction of the cake was left? What happens if the students divide the cake into different amounts? (tenths, twentieths etc.)
- "Number sense with fractions demands more – it requires that students have some intuitive feel for fractions. They should know 'about' how big a particular fraction is and be able to tell easily which of two fractions is larger" (Van de Walle, 2005, p. 74).

VIDEO SEGMENTS

Collaborative Unit Planning

Professional Learning in Mathematics
(3:31)

Cathy Chaput, a Numeracy Facilitator for the Wellington District Catholic School Board, discusses how her work with educators in their board has evolved from their initial involvement in the Collaborative Inquiry for Learning – Mathematics (CIL-M). She explains that unit planning helps teachers see how they can teach through problem solving from day to day, and how they can flexibly adapt their lessons so they are responsive to student learning. Quality unit planning involves conversations that help to deepen the content knowledge necessary for teaching, which ultimately bolsters teacher confidence and student success.

How has professional learning in mathematics evolved in your school?

What do you see as being the next step in your professional learning

Cathy Chaput suggests "it's what goes into the container [the three-part lesson structure] that makes any given lesson particularly effective." What criteria can you use to ensure that your three-part lessons are rich in content and effective for student learning?

The Curriculum
(5:52)

> The curriculum "is based on the belief that students learn mathematics most effectively when they are given opportunities to investigate ideas and concepts through problem solving and are then guided carefully into an understanding of the mathematical principles involved.
>
> *The Ontario Curriculum, Grades 1–8: Mathematics*

The starting point for planning any unit is the Ontario mathematics curriculum. While planning as a junior division, teachers benefit from looking at not only the expectations in Grade 4, 5 and 6, but also the ones from the previous and following grades. This segment highlights how concepts develop over the years, as well as how concepts spiral back, allowing students to consolidate a more solid understanding. Teachers also discover that, in the past, they may have taught beyond what was laid out in the curriculum. As the fraction expectations are discussed, the fundamental ideas underpinning the curriculum emerge. Teachers make the expectations more understandable by putting the ideas in their own words and relating them to real-life contexts.

How can knowing the way in which the fraction curriculum expectations build from grade to grade help to differentiate teaching for students?

What surprised you as the teachers explored the fraction curriculum expectations from grade to grade?

The Big Ideas

(4:54)

> When students construct a big idea, it is big because they make connections that allow them to use mathematics more effectively and powerfully.
>
> *A Guide to Effective Instruction – Number Sense and Numeration, Grades 4 to 6, Volume 1, The Big Ideas*, p. 12

In this segment, Lucy West explains why understanding the *big idea* is so important when planning a unit. Teachers discover that, through planning, they gain a better personal understanding of the fundamental ideas of fractions, and therefore find it easier to meet the curriculum expectations. Cathy Chaput discusses some of the big ideas that are fundamental for acquiring a conceptual understanding of fractions.

After learning more about the big ideas of fractions, try to connect them to other related mathematical concepts and strands. How could you plan your mathematics so that you are reinforcing and linking these ideas throughout the year?

What strategies might you use to help your students distinguish between whole number understanding and the big idea that the numbers in a fraction represent a relationship?

How Concepts Develop

(3:26)

> Because this process of mathematizing is constructive, teachers need to walk the edge between the structure of mathematics and the development of the learner.
>
> Fosnot, 2002

Doug Clements talks about learning trajectories, which highlight the developmental paths that students generally take in their learning. Educators then discuss how this developmental knowledge plays an integral role when planning and implementing a unit. They realize that, rather than thinking that students have forgotten concepts from year to year, it is important to recognize that they may need more experiences at different developmental stages in order to consolidate concepts.

How do the curriculum expectations, Grade 3 to 6, link to the stages and sequences presented in a developmental continuum? (e.g., How do the ideas and wording change from grade to grade to reflect developmental growth?)

Visit the EQAO website and look in the Educator Resources section for questions on fractions from previous assessments. www.eqao.com

The Textbook

(3:21)

In this clip, educators discuss the values of using their textbook as their main resource and how they have found ways to view the textbook "through new eyes" by picking and choosing questions and adapting them to meet the needs of students. The many helpful features of the Teacher's Guide are also highlighted.

What criteria might you and your learning partners use as a guide for analyzing your textbook and determining how to use it most effectively?

The Written Diagnostic

(3:03)

> Making assessment an integral part of daily mathematics instruction is a challenge. It requires planning specific ways to use assignments and discussions to discover what students do and do not understand. It also requires teachers to be prepared to deal with students' responses.
>
> Burns, 2007

In order to plan a unit that is responsive to students' strengths, needs and present understanding, it is beneficial to give some type of diagnostic assessment beforehand. In this segment, the teachers describe how they compiled their written diagnostic and discuss how it helped them to design their unit. At the end of the unit, after implementing the diagnostic for the first time, they reflect on how they could improve their diagnostic for the following year.

What assessment tools might you use throughout a mathematical unit to check for understanding?

The Oral Diagnostic

(13:16)

> Students' understanding is revealed through both oral communication and writing, but it is not necessary for all mathematics learning to involve a written communication component. Young students need opportunities to focus on their oral communication without the additional responsibility of writing.
>
> *The Ontario Curriculum, Grades 1-8, Mathematics*, p. 25

After teachers engage in their own discussion about the importance of knowing what the whole is when dealing with fractions, they decide to give the same diagnostic to students in order to uncover their understanding of this critical concept. This segment shows Grade 4,5 and 6 students discussing the problem:

"Which would you rather have, one-half of a chocolate bar or one-third of another chocolate bar? Why?"

The teachers debrief after observing their students and then discuss the developmental progression that was evident. Several big ideas and misconceptions emerge during this diagnostic. You may wish to view the student segments first and then share your own observations as a group before listening to the comments of the teachers in the video.

What concepts about fractions are well established at the various grade levels?

After listening to the Grade 4 students, which concepts seem fragile and not fully developed?

What are some practical ways of capturing student dialogue and using it to inform the direction of the unit plan?

Building a Collaborative Team

(8:32)

While planning and implementing a unit as a division, teachers need other supports in order for the plan to be effective. In this segment, a principal and special education resource teacher discuss their roles in helping both students and teachers be successful in mathematics.

Lucy West describes the pivotal role that a coach plays in transferring professional talk into action in the classroom. Finally, Lucy West and Cathy Bruce highlight the readiness conditions for professional learning.

How can school schedules be organized to maximize both formal and informal meetings among educators?

What conditions need to be in place in order to build and support trusting relationships as the professional learning progresses?

In what ways can the special education teacher work effectively in the classroom so students with special needs feel comfortable, confident and part of the learning community?

The Big Ideas of Fractions

The Language of Fractions

(6:18)

> The purpose of learning the language of mathematics ... is for communicating about mathematical ideas, and first it's necessary to acquire knowledge about those mathematical ideas. There is no purpose or value for learning mathematical vocabulary without understanding the mathematics it describes
>
> Burns, 2007

Understanding mathematical language and using it are unique and complex tasks. Students must not only understand the words, which can have different meanings in math than in other contexts, but also the numeric and nonnumeric symbols and what they represent. This is especially true for fractions when a 4 underneath a 3 can suddenly become three-fourths just by adding a horizontal line between them. They are no longer whole numbers, but represent a relationship, which may not be understood if standard fractional notation is introduced too soon.

In this segment, teachers discuss the importance of correctly using fractional language terms and how other forms of expression can mask the relationship between the numerator and denominator. This becomes evident in the classroom as students are challenged with making sense of standard fractional notation and its related language.

Before listening to the teacher debrief, watch from 2:47 to 4:19 in the clip. How is the language the girls are using making the task more challenging?

What are some strategies for reinforcing mathematical vocabulary and symbols so the conceptual understanding of what they represent is emphasized?

Fractions as Division

(4:58)

Fractions are often presented as being parts of a whole, represented by an area model. However, other meanings are sometimes overlooked, such as fractions being represented in a set, as a measure and as a ratio. An important meaning, which is not always made explicit, is fractions as division. This is interesting, since division is about sharing, which is quite intuitive, even to very young children. In this segment, teachers discuss this importance of this concept and what the experts have to say about it. Two groups of students then solve a fair-share problem in different ways.

After watching the two groups of students solve the problem presented in the video, compare and contrast their strategies. Why is it so important for ALL students to hear a variety of strategies even though they solved the problem?

What misconceptions might surface as students solve fair-share problems?

Representing Fractions

This series of five segments highlights the various ways that fractions can be represented and how certain representations can be more effective, depending on the task.

Area Models (5:10)

> It may seem ludicrous to think children might generalize that fractions are round, but if their experiences with fractions deal only with fraction "pies," that misconception is not so improbable
>
> Burns, 2007

In this segment, area models are discussed. Research indicates that in North American schools, circles tend to be the predominant way to represent fractions as an area model. This can be problematic since circles are not always easy to divide and partition. Different area models are highlighted and discussed.

What other area models would be meaningful to your students other than the circle and the rectangle?

Set Models (4:10)
As teachers analyze their diagnostic, they learn that their students have some misconceptions about set models. This important concept is therefore addressed in the units at all grade levels. Both teachers and students discover that items of a set do not have to be identical.

What other fractions could be represented by the two visual representations shown at 2:58 and 3:50?

How could tangrams be used to represent both an area and a set model? Why would this be a valuable investigation for your students?

Linear Models (9:29)
This segment focuses on the linear model, which has been proven to be very valuable for developing conceptual understanding, but is often overlooked. Three different linear representations are highlighted, including the number line, fractions towers and Cuisenaire rods.

What concepts in other strands and subjects could be reinforced by using the number line? (e.g., temperature on thermometer, measurement, historic timelines)

Visualization (6:52)

> Another useful skill for students is visualizing the whole when given the fraction ... [it] forces students to 'think the other way around'.
>
> Small, 2009

Visual representations of fractions help students connect fractions to the real world. They also allow students to investigate other concepts, such as complementary fractions, which involves recognizing both the part of a whole that is depicted and the part that is missing. In this segment, Grade 4 students begin to explore complementary fractions, while the Grade 6 class extends earlier experiences by working with visual representations of fractions.

In the Grade 6 task, the ambiguity of the visual representations stimulated rich conversations. In what other ways can ambiguity be embedded into problems?

What concepts are being reinforced when students are exposed to complementary fractions?

How will this exposure help students as they learn the concepts outlined in the curriculum?

How Concepts Develop (1:09)
This segment highlights how fractional representation grows over time using the PRIME developmental map.

How could each of the four representations highlighted in this segment be used to consolidate the importance of knowing what the whole is?

Equivalent Fractions

> With equivalent fraction concepts, students can adjust how a fraction looks so that they can use ideas that make sense to them
>
> Van de Walle, 2006

During this journey, teachers quickly discovered that attaining a strong understanding of equivalent fractions is not easy and takes several experiences over many grades in order for it to become consolidated. They also realized that having a conceptual understanding of equivalent fractions is fundamental for comprehending other big ideas about fractions.

Grade 4 (3:21)
Grade 4 students solve a problem which requires them to name the fractions that make up parts of the whole that they created. By using concrete materials that they can manipulate, some students intuitively discover equivalent fractions. They also naturally uncover the important concept that parts of a fraction in a whole do not have to be adjacent. The educators then debrief their observations.

What might have been the intended learning goals for this lesson?

How might you consolidate this activity so the big ideas that surfaced become more apparent for all students?

Grade 5 (9:34)
In this segment, Grade 5 students find their investigation very challenging, yet the groups actively persevere. The teachers debrief about what was observed. It may be worthwhile to watch the students solving the problem and discuss the following questions before viewing the teacher debrief.

What misconceptions about fractions surfaced in this lesson? What big ideas about fractions can be addressed by using this problem?

From 3:11 to 4:44, the girls decide that 4/18 is an equivalent fraction for 3/8 and that 2/18 is an equivalent fraction for 2/6 and 1/4. How did they arrive at these fractions? Does this indicate that they don't understand equivalent fractions? How do you know?

The students at 6:45 are exploring whether the numerator can be a decimal or a fraction. What questions might you ask them to help them through their thinking?

Grade 6 (3:49)
Through teacher discussion, it becomes evident that equivalent fractions continue to be challenging in Grade 6. A student then demonstrates his understanding of equivalent fractions in a classroom discussion. Cathy Chaput explains that, although we think students forget concepts from year to year, they actually require more experiences at various developmental levels in order to consolidate such big ideas. This growth over time is supported by looking at the developmental progression as outlined in the PRIME developmental map.

Review the Grade 6 curriculum expectations about fractions. Although none of them explicitly mention equivalent fractions, the Grade 6 teacher felt that it was important to spend several days on this concept. What expectations is she also addressing during this time?

At 1:37, a student explains his thinking about a fractional representation. How does his explanation reveal that he has an understanding of equivalent fractions?

Why does a strong understanding of equivalent fractions make it easier to grasp other big ideas about fractions?

When would students use equivalent fractions in their daily lives?

For more activities related to equivalent fractions see *About Teaching Mathematics: A K–8 Resource*, (3rd Edition), by Marilyn Burns

Comparing and Ordering Fractions

> The ability to tell which of two fractions is greater is another aspect of number sense with fractions. That ability is built around concepts of fractions, not an algorithmic skill or symbolic tricks. If students are taught the common denominator rule before they have had the opportunity to think about the relative size of various fractions, there is little chance that they will develop any familiarity with or number sense about fraction size.
>
> Van de Walle, 2006

When teaching students to compare and order fractions, finding a common denominator is often the only method shown to students. These segments highlight other effective means that can be used to carry out related tasks.

Visualization (3:53)
In this segment, students solve an EQAO comparing and ordering problem by using visualization and picturing what the fractions would look like. This is a valuable strategy, since it requires using spatial visualization skills, which are often overlooked and underused.

What other problems would require students to use spatial visualization to estimate fractions?

Spatial visualization is critical for all people in their daily lives, yet it is not explicitly evident in the curriculum expectations. What other mathematical concepts in other strands require strong visualization skills? In what other subject areas could you build and reinforce spatial visualization?

Estimation and Benchmarks (14:42)

> The most important reference points or benchmarks for fractions are 0, ½, and 1. For fractions less than 1, simply comparing them to these three numbers gives quite a bit of information.
>
> Van de Walle, 2006

During the unit planning, educators have a lively discussion about the benefit of linking estimation with benchmarks, and using this knowledge to compare and order fractions. In this segment, students in Grade 4, 5 and 6 use benchmarks and estimation while engaged in tasks that involve comparing and ordering fractions. Teachers debrief on their observations and the growth of this important concept is highlighted using the PRIME developmental map.

In what ways can you link estimation and benchmarks in other strands and subject areas so that students perceive estimation as being useful and relevant to their lives?

Student Strategies (6:53)
In this segment, students apply a variety of interesting strategies including using common numerators and denominators and deriving their own creative ways to compare fractions.

At 2:04 and 6:11, a student describes his strategy for comparing fractions. Try to explain his strategy in your own words. Is his conjecture correct?

Improper and Mixed Fractions

> Activities in which students count fractional parts help them develop an understanding of fractional quantities greater than one whole. Such activities give students experience in representing improper fractions concretely and allow them to observe the relationship between improper fractions and the whole.
>
> *A Guide to Effective Instruction, Number Sense and Numerations, Grades 4–6, Volume 5, Fractions*

Grade 4 (5:22)
While improper and mixed fractions are not specifically addressed in the Grade 4 curriculum, the first segment in this subsection reveals how counting with fractions sets the stage for understanding these important concepts in the later grades.

Why do you think the students in this segment find it so challenging to identify the whole when counting by fifths?

Grade 5 (8:43)
The segment features Grade 5 students working through an investigation which deals with fractions greater than one. Teachers then debrief about some of the challenges and misconceptions that surfaced.

What are the advantages of presenting a question from the textbook in another form, such as on chart paper?

The students at 3:49 have a lively discussion about the problem. What conditions would need to be in place so students can respectfully challenge each other's thinking?

Grade 6 (5:19)
In this segment, Grade 6 students engage in an activity that transitions their thinking from proper fractions to improper fractions and mixed numbers. The problem reinforces the importance of knowing what the whole is, a big idea which students explored earlier on in the unit.

What follow-up activity might you give these students in order to further develop their understanding of improper and mixed fractions?

How could Cuisenaire rods be used to reinforce mathematical concepts in other strands?

Debrief and Reflection

Unit Planning as a Division

(7:41)

After planning and implementing their unit on fractions, the educators reflect upon their experiences with each other and their interactions with their students. They discuss how valuable it is to plan as a division in order to understand the curriculum expectations, the related big ideas and the progression of how concepts develop over time. Rather than viewing each grade in isolation when planning, the educators are able to see the big picture and develop ways to support the learning from one grade to the next. They can also plan for consistency from grade to grade with strategies such as establishing common vocabulary and continually exposing students to a variety of tools and manipulatives. While unit planning does take time, all participants agree that it is a worthwhile investment for their own learning and the success of their students.

What benefits do you see in planning as a division?

Content Knowledge for Teaching

(6:00)

> Pedagogical content knowledge is, "that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special from of professional understanding.
>
> Ball, 2008

In this segment, several professionals and researchers emphasize how important it is for educators to have a strong understanding of the mathematical content in order to effectively help their students acquire conceptual understanding. Teachers explain how unit planning has served as a valuable vehicle for increasing their own understanding of fractions and how concepts develop over time. Their increased knowledge allows them to plan for the

misconceptions that students may encounter and how to help them overcome some of the barriers to understanding.

What strategies might you use with your learning partners to deepen content knowledge?

Student Reflections

(5:23)

> The end of the unit needs to include opportunities for students to consolidate their understanding and connect the new ideas they have learned to mathematical knowledge that they already had.
>
> Small, 2009

In this segment, students in Grade 4, 5 and 6 share their thoughts about what they have learned from the fractions unit and how their previous understandings may have changed from their new experiences. Although the students have acquired a greater understanding of fractions, consolidation takes time – the chance to reel back, engage in more investigations and reflect on them. What will help students attain this goal of conceptual understanding is their increased confidence as they encounter new math challenges in the future.

In the Grade 5 segment, students ask each other questions that naturally lead to reflection. How can this questioning be encouraged and supported in the classroom?

References and Related Reading

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Literature Connections

Although we tend to think of picture books as being mainly used in the primary division, they can be very effective, engaging and thought-provoking in the junior grades. Books can be used an introduction to a concept or to stimulate interest in solving a related problem. The following list includes some of the books that the teachers at St. Joseph shared with their students.

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Notes:

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