Provincial Kindergarten to Grade 5 Numeracy Screening Assessments

Interpretation Guide

Heather Douglas, Ph.D., B.Ed. and Jo-Anne LeFevre, Ph.D.
Department of Cognitive Science
Carleton University

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Contents

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Introduction

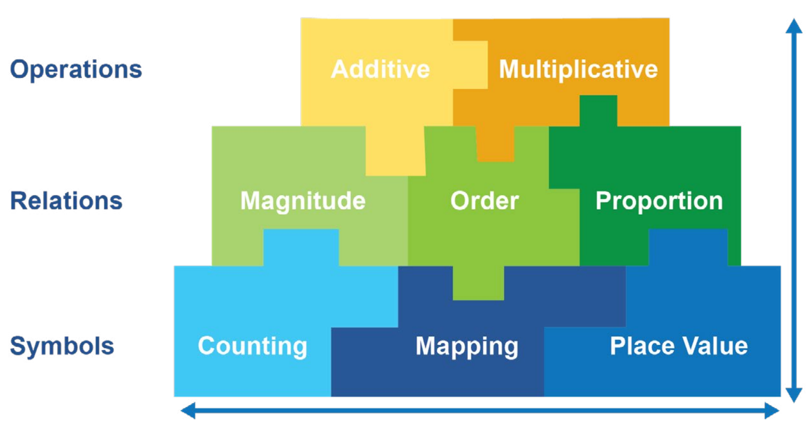
The Provincial Numeracy Screening Assessments are based on Early Math Assessment@School (EMA@School) which is a set of tasks that measures children's and student's developing mathematical knowledge in kindergarten to grade 5. The screeners were designed and continue to be supported by researchers in the AIM Research Centre at Carleton University.

Foundational early mathematical skills include knowledge of symbols, relations, and operations (B. L. Devlin et al., 2022; Jordan et al., 2010). Early symbolic knowledge includes numbers (both words and digits), mathematical vocabulary (such as behind, or half), and math-specific symbols (such as + and =). Relations includes relative magnitude (e.g., $4 < 5$; $6 > 2$), and ordinal relations (1 2 3 …). Operations include arithmetic and comprise both conceptual knowledge (e.g., $4 + 2 = 2 + 4$; commutativity principle) and procedural skills (e.g., $4 + 2 = 6$). The Provincial Numeracy Screening Assessment includes tasks in each of these subdomains. Although skills in each subdomain are related, each predicts mathematics separately and thus can provide independent insights into children and student's numeracy development. Note that tasks are classified according to the major knowledge category they represent, but several tap into more than one knowledge category. The EMA@School currently does not address other areas of skill that are adjacent to mathematics (e.g., spatial skills, geometry), on the assumption that number skills are foundational to mathematical learning (Hawes et al., 2021).

The Theory and Research Behind the Provincial Numeracy Screening Assessments

As described above, the Provincial Numeracy Screening Assessment was designed to capture foundational numeracy skills that support students' acquisition of mathematics from kindergarten to grade 5. Note that there are hierarchical links among the skills. For example, children and students who do not know the number words will not be able to count correctly. Similarly, students who do not understand how fraction magnitudes reflect the relation between the numerator and denominator will do poorly on tasks that require that understanding, such as placing a fraction on a number line. One way of conceptualizing these hierarchical relations among the foundational skills is shown in Figure 1. Each more advanced skill builds upon earlier ones. These interrelations are particularly obvious as children are learning to count. As illustrated in Figure 1, counting is a cornerstone of further numeracy learning (Aunio & Räsänen, 2016). It requires symbol knowledge, and both conceptual and procedural skills. It is often assumed to be an informal numeracy skill in that children and students seem to acquire it without direct instruction, whereas other skills (such as arithmetic) typically involve schooling. However, that assumption is misleading, because counting is complex and requires a long time to master. It is a skill that people continue to use throughout their daily lives but, as adults, we take for granted. Figure 1 shows the skills that students initially learn in relation to whole numbers; notably, the same categories of knowledge apply to rational numbers (i.e., fractions and decimals), which are learned later.

Figure 1. Hierarchical and Integrative Model of Foundational Numeracy Skills



Symbols

Counting

Counting is one of the earliest number skills that children acquire—it involves symbolic knowledge (i.e., the number words), relational knowledge (number order), and operational knowledge (e.g., using counting to add or subtract). Thus, fluent early counting skills provide a framework for further numeracy learning (Aunio & Räsänen, 2016; D. Devlin et al., 2022). Some children arrive in kindergarten with extensive verbal counting skills whereas others are unable to count successfully to five (Litkowski et al., 2020). Because these skills can be acquired at home or in other preschool experiences, they are often referred to as "informal numeracy" (Purpura et al., 2013; Susperreguy et al., 2020) whereas those skills taught in kindergarten and beyond are referred to as "formal numeracy." However, both types of skills are foundational and once children enter school, the distinction fades in importance.

Learning to count involves more than just reciting the count sequence. Children need to acquire conceptual knowledge, most importantly, that the purpose of counting is to determine quantity (Gray & Reeve, 2014, 2016). Researchers have identified five counting principles, three of which are necessary to count successfully, and two which are not essential but show that children have a thorough understanding how counting works.

To use counting in a meaningful way, children need to know and apply the three essential counting principles: a) stable order of the count words (i.e., knowing and using the number words in order), b) one-to-one correspondence between the items counted and the count words (i.e., counting each item once and only once), and c) cardinality: the last number word stated in a count indicates quantity (i.e., how many items are in the set). (Gallistel & Gelman, 1990; Gelman & Gallistel, 1978).

The two non-essential principles are abstraction and order irrelevance. Abstraction is recognizing that a group of objects can be counted even if they are not the same (Siegler, 2003). Abstraction allows children to realize that a set of objects (e.g., with three dogs and four cats) is also a set of seven animals. The order irrelevance principle is that the order in which items are counted doesn't matter—the final count will be the same. Order irrelevance may not be acquired by children until mid-elementary school (Kamawar et al., 2010; LeFevre et al., 2006), long after they are successful counters according to the other rules. Adults typically are confident users of all the counting principles but occasionally will insist on counting in a specific order, typically from left to right (Kamawar et al., 2010).

Should young children use their fingers to count?

The answer to this question is an emphatic yes (Frey et al., 2024). Students who come to grade 1 with better skills typically use their fingers to count. In an intervention study, Frey et al. showed that students with weak numeracy skills in grade 1 who were taught to use finger patterns to represent numbers made more progress than similar students who were not so taught. Of course, finger counting is a temporary support for arithmetic and eventually most students will use it less, or not at all. However, even as adults we use our fingers to keep track of counts, freeing up working memory to name and organize the things-to-be-counted. Fingers are the ideal tool because they are always present, reduce working memory load, and provide a concrete representation of quantity.

Children learn the counting principles gradually from age 2 to 6 (LeFevre et al., 2006; Purpura et al., 2013). Kindergarten screener tasks, Rote Counting and Counting Sets are useful for ensuring that children have the required counting knowledge and skills before the transition to grade 1. The Next Number task, suitable for advanced kindergarten and grade 1 students, requires that students complete a counting sequence. These sequences get progressively more complex, tapping into children and students' knowledge of the rules for generating higher numbers (e.g., 12 13 14 15 ___ ___; which numbers come next?), knowledge of other sequences (e.g., 2 4 6 8 __ __), and fluency of access, allowing them to count backwards (e.g., 10 9 8 7 __ __).

What are the essential counting principles in grade 1?

By the end of kindergarten, children should have mastered the essential counting principles, and hence, understand the purpose of counting; they are expected to verbally count to 10) and to name number symbols to 10[1]. The Provincial Numeracy Screening Assessment can be used to identify which children and students have not mastered these minimal standards. These children and students may need intervention to help them acquire foundational skills. For example, children and students might need pointing and counting practice (for one-to-one correspondence), digit-matching games (for mapping and cardinality practice), counting songs, and other applicable activities. Because these skills are foundational for later learning, teachers can use these *number-knowledge tasks (Rote Counting, Next Number, and Naming Numbers) to identify grade 1 students who are unprepared to learn grade 1 material.*

[1]Specific benchmarks depend on the school district, provincial, state, or country requirements.

Numbers

Starting in grade 1, students are taught about larger numbers (i.e., 10 to 100 to 1 000), although research has shown they also gain knowledge about the structure of large numbers through exposure in everyday life and educational settings (Mix et al., 2023). Students will acquire new rules for mapping number words to number symbols as they are exposed to larger numbers. These rules reflect the structure of the number system, but there can be conflict between the verbal labels and the written symbols, especially in some languages. Consider the French number words for 98: quatre-vingt-dix-huit (which translates to four-twenty-eighteen) compared to "ninety-eight" in English or the equivalent in other languages. Language complexity leads to interesting patterns of behaviour—a familiar number like eighteen is often written as 81 when students are learning. In language such as Dutch or German, where decade numbers such as 42 are named as "two and-forty," such errors are common into grade 2 (Imbo et al., 2014).

Learning is about creating connections. Math learning is cumulative and can be viewed, at least in part, as a hierarchy of connections among numerical and other mathematical symbols (Hiebert, 1988; Núñez, 2017; Xu et al., 2023). Connections between symbols and their concrete representations anchor this hierarchy, for example, knowing that the number 4 represents a quantity of ■■■■. Along with successfully connecting the digit 4 with the quantity ■■■■ however, children and students need to connect the verbal number word "four" with its corresponding number symbol (Hurst et al., 2017; Jiménez Lira et al., 2017). *Mapping* is the term used to describe connecting quantities, digits, and verbal number words. In kindergarten, children complete the Naming Numbers task where they are asked to use verbal number words to name digits. In later grades, the Writing Numbers task reflects the increasing complexity of number symbols, assessing students' knowledge of place value (in the base 10 system), and the imperfect connection between number words and digits. For example, students learning math in French will find mastering the count words from 60 to 99 more difficult than will students learning in English, because of the complex decade structure. Variations in the mapping between number words and digit forms can sometimes influence mathematical learning (LeFevre et al., 2002, 2018).

Beyond the verbal labels and the written symbols, children and students need to understand that the position of a digit indicates its value. Thus, 21 is two tens and one unit, whereas 12 is one ten and two units. Each year, the range of numbers that students learn increases. By grade 2, for example, students are expected to know the number system in the hundreds. A student who hears "two hundred five" and writes "2005" has not yet mastered the rules for transcoding spoken numbers into written digits (Skwarchuk & Anglin, 2002). This common error (called a syntactic error) indicates the student does not understand how the relative positions of written numbers reflect place-value, possibly because they have not learned explicit rules for representing larger numbers (Clayton et al., 2020; Simmons et al., 2012; Sowinski et al., 2015). Children and students with low math performance demonstrate poor understanding of place value rules in the number range they should have learned (Moura et al., 2013). The Writing Numbers task helps teachers identify students' transcoding errors (grades 1 to 5) and determine if they have mastered the place-value rules to the level indicated in the curriculum.

What kinds of mistakes do students make when Writing Numbers?

Teachers can use the Writing Numbers task to identify the kinds of mistakes their students make and identify gaps in students' knowledge of larger numbers (e.g., place value issues; writing two hundred five as 2005 or reversing number order, 28 versus 82). In response to these difficulties, teachers can customize number writing supports as needed, using number-matching games, place-value charts, and other activities that highlight the patterns and rules that determine number structure.

Symbol knowledge

Mathematics is rife with symbols—numbers are only the beginning. Even in grade 1, students are expected to learn symbols such as "=" and "+." Symbol knowledge has three facets: the visual, the verbal, and the meaning. For example, "+" is visual, "plus sign" is verbal, and the meaning is "add."" Research shows that symbol knowledge is a critical aspect of numeracy learning. Every year, students are expected to learn many new symbols, such that by grade 5 students are expected to know, understand, and recognize the symbols for hundreds of mathematical terms (Powell et al., 2021). The Symbol Knowledge task helps teachers determine whether students are acquiring key mathematical knowledge about symbols. In this task, students hear a term, such as “equal sign” and then choose between four possible foils—only one of which is correct. The selection of incorrect symbol foils is based on common student errors such as confusing similar symbols (e.g., < and >), confusing symbols with multiple meanings (e.g.,– ; subtract, negative integer), confusing different symbols with the same meaning (e.g., multiply; *, ×), and recognizing that symbols can mean different things depending on their position (e.g., 3 in x^3, $3x$) (Rubenstein & Thompson, 2001). Connecting the visual, verbal, and meaning of mathematical terms involves language skill and so students whose first language is not the language of instruction may need extra support to learn the correct terms for symbols.

Why use precise mathematical language?

Powell and her colleagues (Driver & Powell, 2015; Hughes et al., 2016; Powell et al., 2019, 2021; Powell & Fluhler, 2018) have done a great deal of research on the importance of mathematical language, which is an important facet of symbol knowledge. In two publications (Hughes et al., 2016; Powell et al., 2019) they provide useful information about the ways in which math language can be made as precise as possible. For example, they recommend not referring to “the numbers” in a fraction such as $\frac{1}{2}$*; instead, say “this fraction is a number” and connect it to the quantity it represents (e.g., on a number line). Fractions represent magnitudes so a fraction is not two separate numbers. Similarly, rather than saying 2 over 3 for the fraction* $\frac{2}{3}$*, they suggest referring to the numerator and the denominator. These researchers stress the importance of teachers using correct, precise mathematical language to refer to mathematical symbols for students with learning difficulties, but this knowledge is important for all students.*

Relations

Numbers can be related to each other in many ways (Merkley & Ansari, 2017). Consider the numerals 1, 2, and 3. These numerals have cardinal (quantity/magnitude) relations (e.g., 3 > 1; 2 < 3), ordinal relations (e.g., 2 comes after 1 and before 3), and arithmetic relations (e.g., 1 + 2 = 3; 3 – 1 = 2). As students acquire various associations among symbolic numbers, including cardinal, ordinal, and arithmetical connections, these associations form an increasingly interconnected mental number network (Hiebert, 1988; Siegler & Lortie-Forgues, 2014; Xu et al., 2019, 2025; Xu & LeFevre, 2021a).

Quick and accurate access to quantities from symbolic numbers supports the development of other number skills like ordinal knowledge, arithmetic, and fractions. For kindergarten to grade 3, relation tasks use whole numbers; from grade 4 to 5, the tasks shift to using rational numbers (fractions and decimals).

Comparing Numbers is a timed task where students quickly and accurately cross off the numerically larger digit in a pair. Comparing Numbers task is used from kindergarten to grade 3, with appropriate modifications in timing. The task combines knowledge of how symbols are connected to quantities with the ability to compare those quantities mentally. Ansari and colleagues have shown that number comparison is a foundational mathematical skill (Hawes et al., 2019; Nosworthy et al., 2013).

What types of activities support student learning when Comparing Numbers?

Children and students in kindergarten and grade 1 with the weakest number comparison skills lack automatic/direct associations between the digit symbols and quantities. For these children and students, teachers provide activities that support linking digits and quantities such as card games like War, board games like Sorry, dice games, or other activities where children and students practice linking visual symbols with quantities (Gasteiger & Moeller, 2021a).

Ordering of Numbers is a timed task where students quickly and accurately judge if three digits are in increasing order (e.g., 2 3 5 vs. 3 1 2). Knowledge of the sequential relations amongst numbers is distinct from knowledge about quantity (Lyons & Ansari, 2015; Lyons & Beilock, 2013). As students’ number relations become more sophisticated and integrated, they can use ordinal skills (e.g., what number comes after 4?) on increasingly complex ordering tasks (Lyons et al., 2014; Xu & LeFevre, 2021b). Ordering of Numbers task is included in the numeracy screener for students in grades 2 and 3. Some students in grade 1 can do the Ordering of Numbers task; however, like children in kindergarten, many find it difficult to understand that non-adjacent numbers such as 2 4 6 are nevertheless “in order” (Hutchison et al., 2022; Xu & LeFevre, 2021b).

What types of activities support student learning of Ordering Numbers?

Teachers can help students develop and use number ordering relations in various contexts such as games involving sequences—ordering numbers, what comes before, what comes next, and so on. Flexibility in using both order and magnitude knowledge to determine if sequences are ordered develops further beyond grade 3 (Lyons et al., 2014). Notably, however, practising arithmetic strategies (e.g., solving 3 + 4 by counting on from 3, 5, 6, 7 also strengthens order knowledge.

Estimating the position of a number on the number-line captures two aspects of a student's mathematical knowledge. First, it measures their understanding of the ordinal relations among numbers (i.e., 3 comes after 2 and before 4; 50 comes after 40 and before 60). Second, number-line estimation requires proportional reasoning skills. Proportional reasoning is used to place the number accurately on the number line (e.g., 49 is close to 50 and 50 is one-half of 100, so an appropriate strategy is to divide the line in half). An example of a number-line question is shown in Figure 2.

Figure 2. *The Numbers on the Number Line Task*

In the Provincial Numeracy Screening Assessment, the Numbers on the Number Line task is used to screen students' developmentally appropriate understanding of ordinal and proportional relations amongst numbers. For kindergarten children, the number range is 0-to-10, for students in grade 1 the range is 0-to-100, for students in grade 2 the range number lines include 0-to-100 and 0-to-1 000 number lines; and for students in grade 3, the number range is 0-to-1000. For students in kindergarten to grade 3, estimation errors greater than 20% (i.e., placing 7 either below 5 or above 9 on a 0-to-10 number line; placing all numbers above 100 near to 1 000) indicates they have a weak grasp of the tested number range (Xu, 2019).

In grades 4, and 5, students see both 0-to-10 000 whole number lines and 0-to-1 and 0-to-2 fraction number lines. These students should show more precise placement than younger students, and so estimation errors greater than 15% index poor understanding. At these later grades, the number lines include fractions. In general, number-line performance is a sensitive index of developing mathematical knowledge (Booth & Siegler, 2006), in part because the task is novel to many students, requiring them to invent a strategy. Proportional reasoning is a superior strategy that is used by more-skilled students whereas less-skilled students will attempt to use counting from either the lower or upper anchor (e.g., 0 or 100 on a 0-to-100 number line), resulting in variable performance across the number-line range (Xu, Di Lonardo Burr, et al., 2023).

What activities can support students' understanding of number magnitudes and number-line locations?

Teachers can support students' understanding of how number magnitudes and number-line locations are connected with activities that promote understanding of ordinal relations, such as linear board games like Snakes and Ladders (Siegler & Ramani, 2009) for younger students, often called "number-path games." In general, number lines are useful teaching tools and provide a concrete representation for learning about fractions and decimals for older students (Jordan et al., 2017a; Rodrigues et al., 2024).

Operations

Procedural fluency and conceptual knowledge of arithmetic principles are mutually reinforcing (Rittle-Johnson & Alibali, 1999). Both types of knowledge are central to the development of strong mathematical understanding (Crooks & Alibali, 2014; Fyfe et al., 2012). Thus, students' acquisition of the arithmetic operations are foundational predictors of later fraction and algebra skills (Schneider et al., 2017). To assess these skills in grade 1 and beyond, the Provincial Numeracy Screening Assessment includes number facts. In later grades, students complete the Calculation Addition task. These tasks are measures of fluency. Equations is a measure of conceptual knowledge of arithmetic.

Arithmetic fluency reflects how quickly and efficiently students can retrieve number facts or apply efficient strategies (McNeil et al., 2025). Practising arithmetic strategies and increasing fluency strengthens all aspects of early numeracy and supports stronger relational skills. Importantly, arithmetic fluency is a core ability and is closely related to many other mathematical skills (Price et al., 2013), including problem-solving (Lin, 2020). Students who know their number facts have more working memory available to focus on the problem they are solving compared to students who need to laboriously calculate simple problems. Importantly, fast and accurate fact retrieval indicates mastery of foundational arithmetic skills, and mastery is a more sensitive metric than accuracy when it comes to monitoring growth in students' skill (VanDerHeyden & Peltier, 2023; Vanderheyden & Solomon, 2023).

What activities can support students' understanding of numbers?

Number Facts tasks include single-digit addition and subtraction (grades 1 to 3), and multiplication and division (grade 4 and higher). These tasks identify students with weak arithmetic fluency (addition, subtraction, multiplication, division). Performance on the Number Facts task can be used by teachers to gauge the current arithmetic skills of their group of students and plan lessons accordingly. Teachers can support fact fluency with card or board games (e.g., cribbage), classroom practice, and other applicable activities (Gasteiger & Moeller, 2021b). Access to online, gamified practice supports students' fluency, but there are many other ways to encourage mastery of number facts including practicing timed retrieval (Codding et al., 2011; Riccomini et al., 2017). Building fluency early can also reduce or prevent math anxiety because students realize that they can be successful (Codding et al., 2023).

Calculation Addition includes multi-digit addition and is a measure of students' computation skills and their understanding of place value. To solve these problems, students need to manipulate the numbers. They can use standard algorithms or other strategies such as breaking the number down (e.g., 83 + 27 = [7 + 3] + [80 + 20] = 110). As students' number skills develop, their solution strategies become more efficient (Hickendorff et al., 2019). To quickly and efficiently solve calculation problems that involve regrouping, students need to process place-value information. Students who experience math difficulties take more time and make more errors when solving multi-digit arithmetic problems than their peers (Lambert & Moeller, 2019).

Equations assess students' knowledge of five arithmetic principles. These include the basic principles of identity (i.e., adding or subtracting zero or multiplying or dividing by 1 does not change the number), and negation (i.e., subtracting a number from itself equals 0 or dividing it by itself equals 1 (Robinson, 2017). The principle of inversion arises from an understanding of identity and negation, such that students can easily solve problems like 3 + 54 – 54 and 21 x 5 ÷ 5 without calculating (Crooks & Alibali, 2014; Robinson & LeFevre, 2011).

Two other principles, commutativity and equivalence, allow students to flexibly evaluate equations presented in a variety of formats. Commutativity is the principle that the order of operands in addition doesn't matter, so that 3 + 4 will have the same answer as 4 + 3. Students implicitly understand this principle when they know they can solve both 2 + 5 and 5 + 2 by counting on from 5 (Siegler & Braithwaite, 2017). Multiplication is also commutative, and that understanding can be used to simplify learning the answers to multiplication facts. There are half as many facts to learn when students are taught the "small x large" facts and the commutativity rule (Campbell & Xue, 2001; LeFevre & Liu, 1997).

Equivalence is the rule that the information on both sides of an equation must be equal. Equivalence is signalled by the equal sign and it is fundamental for flexible thinking about numbers (Kirkland et al., 2024) and for learning algebra (Crooks & Alibali, 2014; Star & Rittle-Johnson, 2008). Knowledge of equivalence starts out very simply, (e.g., knowing that 4 = 4 is a valid equation). At first, students may think that the equal sign in a problem like 3 + 2 = __ means something like "add these two numbers and put the answer in the blank space." That operational notion must be replaced by a relational understanding—the equal sign really means "the quantity on the left side and the quantity on the right side should be the same." This relational understanding is critical but does not fully develop until grade 6 or later in many countries (Simsek et al., 2021). Students who acquire relational understanding earlier and therefore develop flexible problem-solving skills will find learning about fractions, decimals, and algebra easier (Crooks & Alibali, 2014; McNeil et al., 2006; Prather & Alibali, 2009).

What type of activities supports student learning of equations?

The Equations task provides information about which principles are familiar to students. Helping students to learn these principles and become flexible problem-solvers will prepare them for learning about fractions and algebra in later grades (Robinson & Dubé, 2012). Providing frequent opportunities for students to see equations in many different forms and fostering a relational interpretation of the equal sign will support students' progress (Star & Rittle-Johnson, 2008). Even older students may need to be reminded about the meaning of the equal sign when they encounter it in new contexts.

Rational numbers

Whole number knowledge forms the foundation for building strong rational number skills (i.e., fractions, decimals, and percentages) and prepares students for later mathematical success (Malone et al., 2019). Fraction skills predict students' later understanding of algebra, and their overall math achievement in high school (Booth & Newton, 2012; Jordan et al., 2017b; Siegler et al., 2013). The Rational Numbers task measures students' understanding of how fraction symbols connect to fraction magnitudes, that is, how fraction symbols are related to the quantities they represent.

The magnitude of a fraction is based on the relation between the numerator and denominator (i.e., ($\frac{3}{8} < \frac{1}{2}$ even though 3 > 1 and 8 > 2). Thus, even though each fraction includes two or more numerals, the fraction symbol represents a number (i.e., a single magnitude). Whole number knowledge can make it difficult for students to grasp how fraction symbols represent magnitude. Those students who are less skilled will show evidence of this "whole number bias" (Braithwaite & Siegler, 2023; Siegler & Braithwaite, 2017).

Fractions are also complex in that they are used to represent multiple different quantities. For example, ($\frac{3}{8}$ can represent a discrete quantity (3 out of 8 students), part of a whole (3 slices of an 8-slice pizza) or a continuous quantity ($\frac{3}{8}$ of a litre).

Finally, unlike whole numbers, fractions with different integers can describe the same magnitude (e.g., ($\frac{3}{8} = \frac{6}{16}$). Students' ability to inhibit their knowledge of whole number concepts may predict their fraction understanding (Di Lonardo Burr et al., 2022b; Xu, LeFevre, et al., 2023). In the Rational Numbers task, students match quantities to fractions or decimals and compare magnitudes and orders and a single score is produced. However, teachers can explore performance across the individual items, allowing them to see exactly which aspects of rational number knowledge are weak among their students.

What are some of the common fraction and decimal errors that students make?

Students' mistakes can provide information about gaps in their understanding. Teachers can address these misconceptions directly and help students to develop strong conceptual knowledge about fractions (Deringöl, 2019). Certain errors are particularly common.

1. ***Fractions: Confusing the denominator and the numerator.*** *When representing fractions, students may misunderstand what the numerator and denominator represent. For example, a student may incorrectly identify 3 out of 8 slices of pizza $\frac{3}{5}$, or even $\frac{5}{8}$.*

2. ***Fractions: Using whole number knowledge to interpret fraction magnitudes.*** *Students may not understand that the magnitude of the fraction is based on the relation between the numerator and denominator. Instead, they may rely on their understanding of whole numbers to compare fractions. For example, students may assume that a larger denominator indicates a larger fraction (e.g., thinking $\frac{1}{3}$ is greater than $\frac{1}{2}$), or a larger numerator indicates a larger fraction (e.g., thinking $\frac{5}{8}$ is greater than $\frac{2}{3}$), or they might look at the gap between the numerator and denominator and assume a smaller gap indicates a larger fraction (e.g., thinking $\frac{2}{3}$ is greater than $\frac{7}{9}$) (Di Lonardo Burr et al., 2022a; Rinne et al., 2017). Showing fractions on a number line and having students compare the quantities shown can be helpful in overcoming the whole number bias.*

3. ***Decimals: Place-value confusion.*** *Students may confuse the number of digits with the size of the number in decimal numbers. For example, they may think that 0.3 is smaller than 0.27 because 3 is smaller than 27.*

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