Areas of Strengths and Growth Opportunities for Students Who Achieved Level 2 on the Mathematics Component of the 2022–2023 EQAO Assessment of Reading, Writing and Mathematics, Junior Division

Introduction

This study provides detailed information regarding students' mathematical strengths and growth opportunities from the mathematics component of the 2022–2023 Assessment of Reading, Writing and Mathematics, Junior Division, with a focus on students achieving Level 2.

This work expands on EQAO's previously released Student Achievement on Mathematics Curriculum Strands (Education Quality and Accountability Office [EQAO], 2023b) by analyzing student responses to multiple-choice questions to identify strengths and potential growth opportunities in mathematical understanding. Detailed examples are provided to illustrate student misunderstandings as well as instructional implications and recommendations that educators can use to move student achievement from Level 2 to the provincial standard. Although the analysis provided in this report focuses on students at Level 2, the themes and instructional implications that emerge are useful for all students, as they highlight areas required for strong mathematical understanding.

Method

The data used for this study include responses from all participating students at public school boards in Ontario who received an assessment level outcome from the mathematics component of EQAO's junior-division assessment in the 2022–2023 school year.

In the junior-division mathematics component, each student is presented with 44 operational and four field-test questions. These questions assess student knowledge and skills across the Number, Algebra, Data, Spatial Sense and Financial Literacy strands.[1] As outlined in the Assessment of Reading, Writing and Mathematics, Junior Division, Framework (EQAO, 2025a), 32% of the 44 operational questions are allocated to the Number strand, 20% to the Algebra strand, 18% to the Data strand, 20% to the Spatial Sense strand and 9% to the Financial Literacy strand. Each question is also mapped to one of three of the categories of knowledge and skills: Knowledge and Understanding, Application or Thinking.

The mathematics component of the junior-division assessment uses a multi-stage computer adaptive testing model (EQAO, 2020) that adapts to student performance as the student progresses through the stages. The assessment is composed of different types of selected-response questions such as drag and drop, drop-down menu, ordering, checklist, and single- and multiple-selection questions (EQAO, 2025a). For this study, only multiple-choice questions were included in the analysis from the five assessed strands and three knowledge and skills categories. Field-test questions were not included. This resulted in the selection of 86 operational questions for an item-by-item analysis as outlined below.

The item-by-item analysis was conducted by calculating the percentage of students at each achievement level who selected each answer option for each question. Response patterns were then examined to understand the potential mathematical misunderstandings and misconceptions that led students to select incorrect answers.

Table 1 provides an example of the analysis process for one question, in which the percentage of students who selected each option is calculated for students at each achievement level. In Table 1, 20% of students achieving Level 2 selected option A as opposed to the correct option C. Option A was then analyzed to determine why students might have selected it and what this selection revealed about potential mathematical misunderstandings and misconceptions.

Students achieving below Level 1 were not included in the analysis due to small sample sizes. Responses for students in English- and French-language schools were analyzed separately, and major differences are described in detail in this report where applicable.

Table 1. Percentage of students who chose each option, by achievement level

Level	A	B	C	D	No Response	Total
Level 1	24%	27%	33%	15%	1%	100%
Level 2	20%	13%	59%	7%	1%	100%
Level 3	7%	2%	89%	2%	–	100%
Level 4	1%	–	99%	–	–	100%

Findings

Classification of Mathematical Themes

Through the analysis of item level performance, patterns of students' mathematical understanding were grouped under four themes: Proportional Reasoning, Algebraic Reasoning, Computational Thinking and Mathematical Language. By grouping mathematical understanding into these four areas, student strengths and areas for growth were identified. Each of these themes will be explored in detail in the following sections by using examples from the Resource: Released Questions, Assessment of Reading, Writing and Mathematics, Junior Division (EQAO, 2023a). As well, instructional implications and recommendations for improving student performance are provided for each theme.

Theme 1. Proportional Reasoning

One of the most prevalent and noticeable themes that appeared during the analysis of student responses was proportional reasoning, which “permeates mathematics and is often considered the foundation to abstract mathematical understanding” (Ontario Ministry of Education, 2012, p. 2). As such, proportional reasoning appears across the Ontario mathematics curriculum. It is defined as “reasoning that is based on equal ratios and that involves an understanding of the multiplicative relationship in the size of one quantity compared with another” (Ontario Ministry of Education, 2020b, p. 567).

When examining the answer choices of Grade 6 students at Level 2 within the context of proportional reasoning, both strengths and areas for improvement became apparent. In terms of strengths, students achieving Level 2 were able to multiply and divide accurately in single-step tasks using whole numbers. Areas for improvement for students achieving Level 2 were apparent in questions involving unit conversion, comparing fractions and decimal numbers, equivalent fractions, and the multiplication of three-digit whole numbers by decimals. The examples below explore each of these findings in detail.

Unit Conversion

Students achieving Level 2 struggled with questions involving unit conversion. When presented with questions that required the conversion of larger units to smaller units (e.g., kilograms to grams, litres to millilitres, and metres to centimetres or millimetres) and vice versa, only one quarter of students achieving Level 2 answered correctly as compared to two thirds of students at Level 3. Example 1, taken from the *Resource: Released Questions, Assessment of Reading, Writing and Mathematics, Junior Division* (EQAO, 2023a), illustrates this finding and how students struggled with the proportional scaling of metric units.

Example 1

(Resource: Released Questions, Grade 6 Assessment of Mathematics, Question 26)

A group of 6 students share 3 L of water equally.

How many **millilitres** of water does each student receive?

A 50 mL

B 500 mL

C 2000 mL

D 3000 mL

Objective: Students were asked to determine how a group of six students will equally share the given amount of water in millilitres.

Overall Curriculum Expectation: E2, Measurement. To answer correctly, students need to "compare, estimate, and determine measurements in various contexts" (Ontario Ministry of Education, 2020b, p. 373).

Mathematical Misunderstanding: When answering this type of question, students achieving Level 2 often selected options that indicated difficulty with unit conversion. In this example, students often selected option A, indicating that they had incorrectly converted 3 L to 300 mL and then divided by six to arrive at 50 mL. Difficulties with metric unit conversion also appeared in questions that asked for conversions of centimetres to metres and kilograms to grams, indicating the need for instructional supports in unit conversion.

Comparing Fractions and Decimal Numbers

Students achieving Level 2 often struggled with comparing fractions and decimal numbers. When presented with questions that asked students to compare fractions with different denominators and fractions to decimals, only one quarter of students achieving Level 2 answered correctly as compared to two thirds of students achieving Level 3. Example 2 illustrates these findings, and the difficulties students had when comparing fractions and converting fractions to decimal numbers.

Example 2

(Resource: Released Questions, Grade 6 Assessment of Mathematics, Question 3)

Select **TWO** numbers that are greater than $\frac{5}{2}$.

A $2\frac{1}{3}$

B $2\frac{3}{5}$

C 2.399

D $\frac{8}{4}$

E 2.65

Objective: Students were asked to select two numbers that are greater than $\frac{5}{2}$.

Overall Curriculum Expectation: B1, Number Sense. To answer correctly, students need an "understanding of numbers and make connections to the way numbers are used in everyday life" (Ontario Ministry of Education, 2020b, p. 327).

Mathematical Misunderstanding: When answering questions of this type, students achieving Level 2 often selected options that indicate that they had not treated the fractions as quotients to compare them to each other and the other decimal numbers. Students often selected option C, the number with the most digits, instead of one of the correct options (B and E). This misconception involving decimal numbers means that students may be applying whole-number concepts to decimal numbers, which indicates the need for instructional support in this area.

Equivalent Fractions

Students achieving Level 2 also struggled with questions that required an understanding of equivalent fractions. For example, students could be presented with questions in which they were asked to calculate the probability of selecting a red tile from a bag of 10 red tiles and five yellow tiles. When option choices were displayed as fractions that required finding the equivalent of $\frac{10}{15}$ (i.e., $\frac{2}{3}$), students often selected options like $\frac{1}{15}$, indicating a misunderstanding of the proportional nature of the question, which is required for probability calculations.

Multiplication of Three-Digit Whole Numbers by Decimals

Students achieving Level 2 also had difficulties with the multiplication of three-digit whole numbers by decimals. When presented with questions that required students to calculate the total weight of 120 objects that had a mass of 2.1 kg each, students often selected options like 122.1 kg (= 120 + 2.1) instead of multiplying 120 by 2.1 to arrive at the correct answer. Mathematical errors of this nature highlight the importance of the development of proportional reasoning skills and the distinction between additive and multiplicative thinking (Lamon, 2012; Ontario Ministry of Education, 2012).

Implications and Recommendations for Proportional Reasoning

Proportional reasoning appears across the Ontario mathematics curriculum and "is often considered the foundation to abstract mathematical understanding" (Ontario Ministry of Education, 2012, p. 2). This widespread nature is evident in the examples provided above, which detailed student difficulties in questions mapped to different strands across the curriculum. A key aspect that appeared in the analysis was the tendency for students who struggled with proportional reasoning to use counting or additive methods for questions that involved multiplicative thinking, which "requires thinking about situations in relative rather than absolute terms" (Ontario Ministry of Education, 2012, p. 5). Developing multiplicative thinking is not only important for answering mathematical problems that require multiplication and division, but also has implications for understanding relationships between quantities and for learning in the Algebra, Spatial Sense, Data and Financial Literacy strands.

Recommendations

- Make use of multiple assessment types and opportunities to determine which aspects of proportional reasoning students already know, and what next steps are needed to reach each student's learning goals. This could include the use of EQAO's released questions from the Released Questions with Provincial Data: Mathematics (EQAO, 2025b) that involve proportional reasoning as part of a pre- and post-assessment.
- Allow students to practise with a variety of proportional tasks in multiple contexts across strands that foster connections across mathematical topics. This practice could include engaging students in scaling up and down problems (i.e., problems involving growing and shrinking patterns) that include whole numbers, decimals and fractions.
- Consider activities with math manipulatives (including virtual manipulatives) that allow students to explore different proportional and non-proportional problems. This could include classifying additive and multiplicative problems, followed by classroom discussion (Van Dooren et al., 2010).

Theme 2. Algebraic Reasoning

Algebraic reasoning appeared as an important theme during the analysis of student responses. The Ontario Ministry of Education defines algebraic reasoning as "our ability to notice patterns and generalize from them. Algebra is the language that allows us to express these generalizations in a mathematical way. Formulas, such as the area of a rectangle = length × width ($A = l \times w$), are derived through such generalizations" (Ontario Ministry of Education, 2013, p. 3).

When examining the answer choices of Grade 6 students at Level 2 within the context of algebraic reasoning, areas for improvement became apparent. These include the use of expressions and inequalities, an understanding of formulas and finding unknown angles. The examples below illustrate each of these growth areas.

Use of Expressions and Inequalities

Students achieving Level 2 struggled with solving expressions involving inequalities and the substitution of variables. When presented with questions similar to Example 3, only 30% of students at Level 2 answered correctly as compared to 60% of students at Level 3. Mathematical misunderstandings in questions like this example often involved students directly substituting numbers instead of performing operations (multiplication) as well as a misunderstanding of inequality symbols.

Example 3

(Resource: Released Questions, Grade 6 Assessment of Mathematics, Question 11)

Select the value for x that makes this inequality true.

$3x - 6 > 30$

A $x = 6$

B $x = 10$

C $x = 12$

D $x = 13$

Objective: Students were asked to select the value for x that makes the inequality true.

Overall Curriculum Expectation: C2, Equations and Inequalities. To answer correctly, students need an "understanding of variables, expression, equalities, and inequalities, and apply this understanding in various contexts" (Ontario Ministry of Education, 2020b, p. 354).

Mathematical Misunderstanding: The correct response for this question, option D, involves substituting 13 for the variable x, then multiplying 3 by 13 to arrive at 39, and then subtracting 6 to arrive at 33, which is greater than 30. However, many students achieving Level 2 selected options that indicate they had misunderstood the 'greater than' symbol (>) to mean 'equal to' (=). They selected option C ($3 \times 12 = 36$, then $36 - 6 = 30$), or option A, in which they had misunderstood both the inequality symbol and multiplication of variables: (3(6) becomes 36, then $36 - 6 = 30$). These results point to the importance of students developing a thorough understanding of how variables are used to represent unknown quantities and solving inequalities that involve operations. Knowledge of symbol terminology is also important here and is explored in more detail in the Mathematical Language theme.

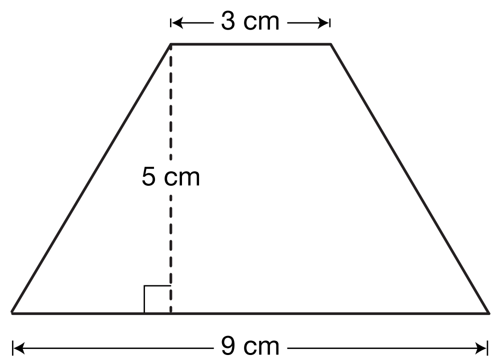
Understanding of Formulas

Students achieving Level 2 also struggled with applying formulas to calculate area. For example, when presented with questions that required the calculation of the area of a trapezoid, only one third of students achieving Level 2 were able to correctly answer the question as compared to two thirds of students achieving Level 3. Even though the formula was provided in the junior-division formula sheet, students who had difficulty with these types of questions tended to use the more familiar formula for the area of a rectangle. Example 4 explores the options chosen by students in more detail.

Example 4

(Resource: Released Questions, Grade 6 Assessment of Mathematics, Question 25)

What is the area of this trapezoid?



A 15 cm^2

B 30 cm^2

C 45 cm^2

D 60 cm^2

Objective: Students were asked to calculate the area of a trapezoid.

Overall Curriculum Expectation: E2, Measurement. To answer correctly, students must “compare, estimate, and determine measurements in various contexts” (Ontario Ministry of Education, 2020b, p. 373).

Mathematical Misunderstanding: The correct response for this question, option B, involves use of the formula for calculating the area of a trapezoid ($A = (b_1 + b_2) \times h \div 2$). However, many students at Level 2 selected option C, in which they multiplied 5 and 9 using the calculation for the area of a rectangle ($A = b \times h$) to arrive at 45 cm^2. These results point to the importance of students developing a conceptual understanding of the relationship represented by geometric formulas.

Finding Unknown Angles

Finding unknown angle measures that involved the use of equations and expressions was also an area of improvement for students achieving Level 2. For example, when presented with questions where students were asked to find an unknown interior angle of a quadrilateral, students at Level 2 were less likely to add the known interior angles and then subtract this value from 360° to find the missing angle. Students who struggled with this concept tended to select options that indicated they were unfamiliar with using angle properties to solve for unknown measures.

Implications and Recommendations for Algebraic Reasoning

By exploring the properties of numbers and then developing an understanding of patterns, students build the generalization rules of algebra (Ontario Ministry of Education, 2013). In addition to generalization, algebraic reasoning also includes an understanding of unknowns expressed as variables, as well as a conceptual understanding of formulas and equivalence (Ontario Ministry of Education, 2013). The examples explored above illustrate the difficulties students had in these areas and highlight the importance of developing algebraic reasoning as students progress in their learning of mathematics concepts. Without consistent skills in algebraic reasoning and an understanding of variables and formulas, solving algebra problems becomes more difficult. These skills are needed to build equations and to solve an equation for an unknown or missing value.

Recommendations

- Develop students' conceptual understanding of angle rules through direct instruction using a wide variety of representations and contexts. For example, consider making explicit connections to algebraic representations of angle rules such as $x + 60 = 90$ (complementary angle rule).
- Use physical manipulatives to allow students to develop a concrete representation of algebraic ideas (Ontario Ministry of Education, 2013). For example, educators can consider using algebra tiles to practise manipulating equations and inequalities with whole numbers, thus allowing students to model and solve equations visually. With manipulatives, students can first apply operations concretely, then transfer their concrete skills to pictorial representations and, finally, move to more abstract representations by using algebraic symbols (Fyfe et al., 2014). This three-step progression allows students to build a repository of memorable images to reference when abstract concepts become more difficult to understand (Fyfe et al., 2014).
- Consider providing opportunities for students to discuss and analyze algebraic problems that have already been solved so they can compare different solution strategies and the mathematical reasoning involved (Star et al., 2015).

Theme 3. Computational Thinking

Our next theme explores computational thinking, which can be defined as "the thought process involved in expressing problems in such a way that their solutions can be reached using computational steps and algorithms" (Ontario Ministry of Education, 2020b, p. 513).

When examining the option choices of students at Level 2, it became clear that students struggled with multi-step questions in general, and particularly those that involved applying operations with different relationships between numbers. The examples below explore these findings in more detail.

Applying Operations

Students achieving Level 2 struggled with questions that involved applying operations across more than one step. When presented with questions that required multiplication and division performed in the correct sequence, only approximately 50% of students at Level 2 answered correctly as compared to 90% of students at Level 3. Example 5, taken from the *Resource: Released Questions, Assessment of Reading, Writing and Mathematics, Junior Division* (EQAO, 2023a), illustrates this finding and how students struggled with the selection of the correct operation in the correct sequence in order to solve the question.

Example 5

(Resource: Released Questions, Grade 6 Assessment of Mathematics, Question 6)

A store receives 12 cases of tomatoes.

Each case contains 14 tomatoes.

All of the tomatoes are put into bags.

Each bag can hold 6 tomatoes.

How many bags of tomatoes will the store have?

A 2 bags

B 7 bags

C 25 bags

D 28 bags

Objective: Students were asked to calculate the number of bags of tomatoes a store will have if each bag can hold six tomatoes and the store receives 12 cases of tomatoes containing 14 tomatoes each.

Overall Curriculum Expectation: B2, Operations. To answer correctly, students must "use knowledge of numbers and operations to solve mathematical problems encountered in everyday life" (Ontario Ministry of Education, 2020b, p. 335).

Mathematical Misunderstanding: When answering questions of this type, students achieving Level 2 often selected options that indicated difficulty with selecting the correct operation to fit the situation. In this example, students at Level 2 often selected option B, indicating that they had multiplied the number of tomatoes in each case by the number each bag can hold ($14 \times 6 = 84$) and then divided it by 12 to arrive at 7. These students correctly performed the division and multiplication but misunderstood when to use each operation. In this multi-step question, students need to identify and solve both of the calculations needed to arrive at the correct answer: first, determine the total number of tomatoes ($12 \times 14 = 168$) and then determine the number of bags needed for the tomatoes ($168 \div 6 = 28$). Students who struggle to identify the correct operation and which quantities to use in each step will find questions of this nature difficult to solve because of the different relationships between the numbers presented.

Multi-Step Calculations

Analysis of option selections revealed that students achieving Level 2 struggled with questions that required not only an understanding of the mathematical concepts but also with planning sequential steps for questions that required multiple calculations to answer correctly. Approximately one third of students at Level 2 were able to answer questions of this type correctly as compared to about 90% of students at Level 3. Example 6 illustrates how students at Level 2 struggled with this type of multi-step question.

Example 6

(Resource: Released Questions, Grade 6 Assessment of Mathematics, Question 9)

Two patterns are shown.

Pattern A

4, 12, 36, 108, ...

The pattern continues to grow in the same way.

Pattern B

21, 49, 77, 105, ...

The pattern continues to increase by the same amount.

How much **greater** is the term value of the 6th term in Pattern A than the 6th term in Pattern B?

A 191

B 648

C 811

D 972

Objective: Students were asked to compare the sixth terms in two patterns and determine how much greater the term value was in Pattern A than the term value in Pattern B.

Overall Curriculum Expectation: C1, Patterns and Relationships. To answer correctly, students must "identify, describe, extend, create, and make predictions about a variety of patterns, including those found in real-life contexts" (Ontario Ministry of Education, 2020b, p. 349).

Mathematical Misunderstanding: When presented with questions of this nature, students at Level 2 who answered incorrectly often selected options that indicated they had completed only one or some of the steps required to correctly solve the question. In this example, the correct response is option C, in which students have determined what the pattern rules are, calculated the sixth term value in each pattern and then compared the term values to determine the difference. There is more than one way to solve this question; however, common misunderstandings involve students selecting option A, in which the fifth term values are used to determine the difference. Misunderstandings of this nature highlight the importance of students being able to plan a solution strategy for multi-step questions that involves determining what the question is asking, what information or calculations are needed, and then checking the correctness of their solution.

Implications and Recommendations for Computational Thinking

Students develop computational thinking skills by analyzing problems, identifying patterns, designing algorithms and testing solutions (Aho, 2012; Grover & Pea, 2013; Weintrop et al., 2016; Wing, 2006). These skills have many instructional implications since they are essential for success in science, technology, engineering and mathematics (STEM) and related fields (Aho, 2012; Grover & Pea, 2013; Weintrop et al., 2016; Wing, 2006). One of these computational thinking skills is problem solving, which allows students to break down more complex mathematical problems into smaller and more manageable parts (decomposition) (Wu et al., 2024). The examples explored above indicate that these decomposition skills are a growth area for students achieving Level 2.

Recommendations

- Make the process of problem solving explicit by discussing the thinking process with students (Ontario Ministry of Education, 2020a). Encourage students to share their thinking process by exploring the structure of a multi-step problem to determine what information has been provided and what information is needed, and to compare different solution strategies (Ontario Ministry of Education, 2020a).
- Regularly review and offer practice on difficult concepts such as solving problems with multiple operations. This practice should not only revisit students' prior knowledge but allow students to make connections between the skills, concepts and processes (Ontario Ministry of Education, 2020a).
- Support students with solving new problems using anchor charts that model different problem-solving situations (Ontario Ministry of Education, 2020a).

Theme 4. Mathematical Language

The final theme explored in this report is mathematical language, which can be defined as "the conventions, vocabulary, and terminology of mathematics" (Ontario Ministry of Education, 2020b, p. 548). When examining the option choices of students at Level 2, strengths were identified in mathematical language. This included an understanding of the concept of donating within the Financial Literacy strand. For example, most students understood that donating was not a method to earn income through employment.

It also became apparent through the analysis that students at Level 2 struggled with questions that required knowledge and understanding of the mathematical content and associated mathematical language within some questions. This occurred across strands and was found for certain terminology within data visualizations, measures of central tendency and range, geometry, graphing relationships and coordinates of a coordinate plane.

Terminology in Data Visualizations

Students at Level 2 often struggled with the terminology used to differentiate different graph types. Approximately 30% of students achieving Level 2 answered these types of questions correctly as compared to 60% of students achieving Level 3. Example 7 illustrates these types of questions and the options selected by students who struggled in this area.

Example 7

(Resource: Released Questions, Grade 6 Assessment of Mathematics, Question 15)

Which type of graph would **best** show the change in monthly precipitation over a period of 6 months?

A histogram

B line plot

C broken-line graph

D pictograph

Objective: Students were asked to select the type of graph that would best show change in monthly precipitation over a period of six months.

Overall Curriculum Expectation: D1, Data Literacy. To answer correctly, students must "manage, analyse, and use data to make convincing arguments and informed decisions, in various contexts drawn from real life" (Ontario Ministry of Education, 2020b, p. 360).

Mathematical Misunderstanding: When presented with questions of this nature, students who answered incorrectly often selected options that indicate they did not have a good understanding of which graphs are best suited to represent different data sets. The correct response is a broken-line graph (option C), as these graphs are used to represent data that change over time. Students who struggled with these types of questions often selected graphs that they may have been more familiar with, such as a pictograph (option D).

Terminology in Measures of Central Tendency and Range

Students at Level 2 also struggled with measures of central tendency and range, particularly the mean, as illustrated by Example 8. When presented with questions of this type, only 25% of students at Level 2 answered correctly as compared to 60% of students at Level 3. Notably, students taking the French-language assessment demonstrated a higher likelihood of selecting the correct response, possibly due to the dual meaning of the term “moyenne,” which translates to both “average” and “mean” in English.

Example 8

(Resource: Released Questions, Grade 6 Assessment of Mathematics, Question 17)

Select the set of numbers that has a mean and range of 11.

A 3, 18, 21, 5, 14, 11, 5

B 9, 8, 16, 11, 8, 18, 7

C 11, 14, 11, 8, 19, 17, 11

D 12, 9, 15, 10, 12, 20, 13

Objective: Students were asked to select the set of numbers that have both a mean and range of 11.

Overall Curriculum Expectation: D1, Data Literacy. To answer correctly, students must “manage, analyse, and use data to make convincing arguments and informed decisions, in various contexts drawn from real life” (Ontario Ministry of Education, 2020b, p. 360).

Mathematical Misunderstanding: Although the correct response was option B, many students at Level 2 incorrectly selected option C, likely due to the mode and range being 11 for this option. Mathematical misunderstandings of this nature underscore the critical importance of distinguishing between range, mean, median and mode, and understanding how each is used to compare data sets.

Terminology in Geometry

Students achieving Level 2 also struggled with the terminology used in geometry, in particular the term “rotational symmetry,” which is essential for describing shape transformations. When presented with questions of this type, only one third of students who achieved Level 2 answered correctly as compared to 60% of students at Level 3. Example 9 illustrates these findings.

Example 9

(Resource: Released Questions, Grade 6 Assessment of Mathematics, Question 22)

Which quadrilateral has two diagonals that bisect each other and has rotational symmetry of order 4?

A rectangle

B square

C parallelogram

D trapezoid

Objective: Students were asked to select which quadrilateral has two diagonals that bisect each other and has rotational symmetry of order 4.

Overall Curriculum Expectation: E1, Geometric and Spatial Reasoning. To answer correctly, students need to be able to "describe and represent shape, location, and movement by applying geometric properties and spatial relationships in order to navigate the world around them" (Ontario Ministry of Education, 2020b, p. 367).

Mathematical Misunderstanding: When answering questions of this type, students achieving Level 2 often selected options that indicate they may not have understood order of rotational symmetry, which is an important concept for understanding geometric properties. Students who struggled with questions of this nature often selected option A (rectangle), in which they may have assumed that the order of rotational symmetry was 4 instead of 2.

Symbols and Terminology Used in Graphing Relationships

Students at Level 2 also struggled with questions that required a conceptual understanding of some of the terminology, symbols and notation used to graph relationships. Examples include the use of inequalities, specifically < and >. As mentioned earlier, Example 3 includes an illustration of the mathematical misconceptions that students at Level 2 experienced with inequalities.

Coordinates of a Coordinate Plane

Students achieving Level 2 also struggled when reading coordinates of a point on a coordinate plane. For example, when answering questions that required using coordinates to describe a location (x, y), students often reversed x and y (y, x) and used the first number in the pair to describe the vertical distance and direction from the origin instead of the horizontal distance. An understanding of the coordinate plane is an important part of the mathematics curriculum and "supports work in geometry, measurement, Algebra, and Data, as well as practical applications such as navigation, graphic design, engineering, astronomy, and computer animation" (Ontario Ministry of Education, 2020b, p. 258).

Implications and Recommendations for Mathematical Language

As mentioned above, students at Level 2 struggled with the symbols and terminology used in data visualizations, measures of central tendency and range, geometry, coordinates of a point on a coordinate plane and graphing relationships. Mathematical language and vocabulary are an important component of student understanding of mathematical concepts and the connections between them (Riccomini et al., 2008). Mathematical vocabulary has been linked to mathematical performance (Lin et al., 2021) and is emphasized in the mathematics curriculum as "students learn the vocabulary and terminology that are unique to a particular subject area and must be able to interpret symbols, charts and diagrams" (Ontario Ministry of Education, 2020b, p. 32).

Recommendations

- Encourage students to use mathematical language in class and provide feedback on its use in written and oral forms. This can provide opportunities for students to build connections to mathematical terms through classroom discourse.
- Use word walls, which can be effective in supporting students as new mathematical concepts and words are introduced (Hattie et al., 2017). For example, visual representations of different data sets, together with their most appropriate graphs with labelled features, can be used to help students understand the differences between different graphs and how they are used to share information.
- Introduce new vocabulary via direct instruction in ways that activate students' prior knowledge (Ontario Ministry of Education, 2020a). For example, students' prior knowledge of number lines and the placement of positive and negative integers can be used during instruction for the four quadrants of a coordinate plane.

Conclusion

Through the analysis of question responses on the mathematics component of the 2022–2023 EQAO Assessment of Reading, Writing and Mathematics for the Junior Division, patterns of students' mathematical understanding and misconceptions were discovered and categorized into four themes: Proportional Reasoning, Algebraic Reasoning, Computational Thinking and Mathematical Language. By grouping mathematical understanding into these four areas, student strengths and areas for growth were identified across the different mathematical curriculum strands. The themes identified in this study revealed opportunities for growth in mathematical understanding and offer recommendations that can be applied systematically, as the skills and concepts discussed are closely connected. For example, improving student ability to solve multi-step problems should not be approached without also addressing difficulties in proportional and algebraic reasoning. Likewise, building mathematical vocabulary is an important activity that can be reinforced across strands.

Other important factors, such as knowing the learner and the curriculum, providing a positive and safe learning environment, using various assessment methods and fostering perseverance in mathematical learning, are also essential aspects of effective mathematical instruction (Ontario Ministry of Education, 2020a). These elements should be included in a systematic approach to improving mathematical proficiency. This report supports educators in getting to know their learners by providing a detailed analysis of the mathematical strengths and growth opportunities for students at Level 2. Educators can further tailor this analysis by using EQAO's released questions within their classrooms to assess current student understanding. Examining student answers to the released questions can uncover possible misconceptions at the student level and inform instructional approaches that address the specific needs of students.

Notes

[1] The assessment does not measure curriculum content from the Mathematical Thinking and Making Connections strand or the Social Emotional Learning (SEL) Skills in Mathematics strand.

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