

Student Achievement on Mathematics Categories of Knowledge and Skills

Results from the 2021–2022

Primary- and Junior-Division and Grade 9 Assessments

OCTOBER 2023

INTRODUCTION

This study explores students' achievement on the mathematics categories of knowledge and skills as assessed by the mathematics components of the primary- and junior-division EQAO assessments and the Grade 9 Assessment of Mathematics. The purpose of the study is to provide further information on students' strengths and needs in mathematics and to assist Ontario's education community in understanding student profiles in mathematics. In particular, this study focuses on differences between mathematics achievement at Levels 2 and 3 on the assessments, as this distinction represents students meeting curriculum expectations (according to provincial standard, Level 3) and those just below. This report presents the study results regarding student performance on three of the categories of knowledge and skills described in the Ontario mathematics curriculum and discusses implications for instructional planning.

METHOD

How results for categories of knowledge and skills are generated

For the 2021–2022 administration, EQAO introduced a multi-stage computer adaptive testing (msCAT) model for mathematics that presents assessment modules to students with the overall difficulty adapted to students' individual ability. Each student's ability level is determined in real time by performance as the student progresses through the assessment.

Because the assessment is adaptive, observed performance is difficult to interpret. This is because the observed percent correct may be similar across msCAT paths, with higher-performing students doing about as well on a set of more difficult questions as lower-performing students do on a set of easier questions. For example, two students of different ability levels may each get 75% of the items on their assessment correct, but 75% correct on a set of more difficult questions indicates a higher level of performance than 75% correct on a set of easier questions.

For this reason, this study reports “expected percent correct” results rather than “observed percent correct” results.¹ Expected percent correct is reported by estimating the percentage of questions each student would get correct if everyone had been administered all the same questions belonging to that curriculum strand. Because we know the difficulty of each question as well as the overall score obtained by each student on the assessment, it is possible to determine what percent of all questions in a curriculum strand are likely (or expected) to be answered correctly by students of varying ability levels.

Population

The responses of all students in Ontario who wrote the adaptive online version of the mathematics components of the primary- and junior- division assessments or the adaptive online Grade 9 Assessment of Mathematics and were provided an achievement level were included in the analysis. Therefore, the data set included 126 660 Grade 3 students, 130 711 Grade 6 students and 72 616 Grade 9 students. (During the 2021–2022 school year, many school boards were not able to administer the Grade 9 mathematics assessment in January, due to the pandemic.)

It is worth noting that the performance of this population of students may look different from that of previous years. The students who wrote the 2021–2022 EQAO assessments had been through COVID-19-related school closures, and students’ in-person learning was interrupted as a result. Because of the new curriculum, instructional time may have been distributed differently than in previous years. Finally, the assessments were online for the first time, and some students may have performed differently due to differential familiarity with the online format.

In addition, this is a single year of data, and it is unknown at this time whether the results for this kind of study will be consistent or differ across years. It is also unknown whether results will be the same across grades when the same students are tracked over time. Similar analyses in future years, and multi-year analyses, will further inform understanding on this topic.

The student populations at English- and French-language boards were combined in this study. This approach was taken because analyses showed that the percentage of correctly answered questions required to achieve Level 3 was the same regardless of language, as all students wrote the same assessment.

Table 1 shows the percentage of students who achieved each achievement level. In total, 59% of Grade 3 students achieved or exceeded curriculum expectations, while this proportion was lower in Grade 6 and Grade 9 (47% and 53% respectively).

Table 1. Percentage of students in the study who achieved each EQAO level, by grade

Grade	Below Level 1	Level 1	Level 2	Level 3	Level 4	N
Grade 3	<1%	8%	32%	46%	13%	126 660
Grade 6	<1%	5%	47%	40%	7%	130 711
Grade 9	<1%	10%	37%	47%	6%	72 616

¹ Throughout the remainder of the report, expected percent correct results are simply referred to as “percent correct” for ease of interpretation.

Categories of knowledge and skills

Three categories of knowledge and skills that are identified in the Ontario mathematics curriculum are assessed on EQAO assessments: Knowledge and Understanding, Application, and Thinking. Communication is a fourth category of knowledge and skills that is not directly assessed on EQAO mathematics assessments.

The Ontario Curriculum gives the following definitions of what the three categories of knowledge and skills represent. The category Knowledge and Understanding represents subject-specific content acquired in each grade or course (knowledge), and the comprehension of its meaning and significance (understanding). The category Application represents the use of knowledge and skills to make connections within and between various contexts. The category Thinking represents the use of critical and creative thinking skills and/or processes.

On the EQAO math assessment components, students demonstrate proficiency in the Knowledge and Understanding category by demonstrating subject-specific content (knowledge) or comprehension of its meaning and significance (understanding), or both, in order to answer the question. These questions assess basic knowledge or understanding of concepts. To demonstrate proficiency in the Application category, students must select an appropriate tool or get the necessary information and “fit” it to the problem. To demonstrate proficiency in the Thinking category, students must either select and sequence a variety of tools (e.g., add first then subtract) or demonstrate a critical thinking process (e.g., reasoning). There may be more than one way to answer these questions.

Overall descriptive statistics are provided below to provide an overview of student achievement on the three categories of knowledge and skills. Note that the number of questions that students receive on their assessment for each category of knowledge and skills varies somewhat depending on which questions the student receives based on their adaptive assessment. However, Table 2 shows the total number of questions available and their distribution across the categories of knowledge and skills. This gives an approximate idea of how the categories of knowledge and skills would be distributed if students answered all questions available.

Table 2. Percentage of questions across categories of knowledge and skills, by grade

Category of knowledge and skills	Grade 3	Grade 6	Grade 9
Knowledge and Understanding	31%	24%	37%
Application	44%	49%	34%
Thinking	25%	27%	29%
Total questions	253	273	357

To provide an overview of student achievement on the categories of knowledge and skills, Tables 3–5 present the descriptive statistics for Grade 3, Grade 6 and Grade 9 respectively. For example, Grade 3 students answered, on average, 70% of Knowledge and Understanding questions correctly, Grade 6 students answered 73% of Knowledge and Understanding questions correctly and Grade 9 students answered 63% of Knowledge and Understanding questions correctly.

However, it is important to understand that the categories of knowledge and skills are not equated on EQAO assessments, which means that it is not possible to compare categories and say that, for example, student achievement is higher for Knowledge and Understanding than for Thinking. There are more “easy” questions on Knowledge and Understanding than Thinking due to the relationship between difficulty and lower- and higher-order thinking skills. Therefore, the number of correct answers required to achieve Level 3 was higher for Knowledge and Understanding than for Thinking. The percent of correct responses required to achieve Level 3 is one of the analyses addressed in this study (see the Analysis section below).

Table 3. Descriptive statistics for each category of knowledge and skills, 2021–2022: Grade 3

Category of knowledge and skills	Mean	Standard deviation	Median	Range
Knowledge and Understanding	69.6	21.54	74	13 to 100
Application	62.6	20.61	64	17 to 100
Thinking	54.3	21.31	54	8 to 100

Number of students = 126 660

Table 4. Descriptive statistics for each category of knowledge and skills, 2021–2022: Grade 6

Category of knowledge and skills	Mean	Standard deviation	Median	Range
Knowledge and Understanding	73.1	17.68	74	27 to 100
Application	59.4	19.30	59	19 to 97
Thinking	49.5	21.59	47	6 to 100

Number of students = 130 711

Table 5. Descriptive statistics for each category of knowledge and skills, 2021–2022: Grade 9

Category of knowledge and skills	Mean	Standard deviation	Median	Range
Knowledge and Understanding	62.9	20.02	63	17 to 100
Application	56.7	19.10	56	17 to 96
Thinking	49.4	22.50	47	0 to 98

Number of students = 72 616

Analysis

The first step in the study was to explore achievement patterns for each category of knowledge and skills among students who achieved different levels. The range of achievement was identified for the middle 50% of students at each level. This was determined by calculating, for each category of knowledge and skills, the percent correct score for the 25th and 75th percentile of students at each level. These results were used to understand the trends in achievement patterns across levels.

The second step in the study was to identify what can be considered a “benchmark” result for each category of knowledge and skills. As Level 3 represents having demonstrated the expected math ability for a given grade, the definition of a benchmark result was anchored on achieving Level 3. It was decided that if a clear majority of students (i.e., 80% of students) at Level 3 achieved a given score or higher, then it was reasonable to say that this score (i.e., the 20th percentile score among students who received Level 3) is required in order to achieve a Level 3. In this study, this score was labelled “the benchmark score” to signify that this is the score schools should be aiming for their classes to achieve on average.

The benchmark scores were first calculated separately for students in English- and French-language boards, and the differences checked. The results were the same or negligibly different between the two language groups. Using the benchmark scores, the percentage of students at other levels (i.e., Level 4, Level 2, Level 1 and Below Level 1) who also achieved this score or higher was calculated.

It was also necessary to know whether achievement of these benchmark scores was required for every skill to achieve Level 3, or just some. To do this, the number of skills where the benchmark score was achieved was calculated for each student. Then the percentage of students who achieved a given number of benchmark scores was reported by level. Profiles for students were also generated to aid in understanding whether there were patterns in their proficiency in different categories of knowledge and skills.

RESULTS

Achievement patterns in categories of knowledge and skills

The first task in the study was to explore achievement patterns in categories of knowledge and skills among students who achieved different EQAO levels in mathematics. The results are reported below for Grade 3, Grade 6 and Grade 9.²

Grade 3

A clear finding is that student achievement was similar across all categories of knowledge and skills. That is, students who were at beginning levels of achievement in one category of knowledge and skills tended to be at beginning levels across all categories of knowledge and skills. Likewise, students who were at the middle or higher levels of achievement in one category of knowledge and skills tended to be at middle or higher levels of achievement across all categories of knowledge and skills.

These relationships are demonstrated in the correlation table below (see Table 6). A correlation value can run from -1 (a perfectly negative relationship) to 0 (no relationship) to 1 (a perfectly positive relationship). A strong relationship is typically over $\pm .40$, and a very strong relationship is typically over $\pm .70$. In the table below, the categories of knowledge and skills show strong or very strong relationships.

² Due to very large sample sizes, statistical significance testing in this study did not yield meaningful results, as even very small differences were flagged as significant. Therefore, results of statistical significance testing (e.g., for correlation coefficients) are not reported.

Table 6. Correlation values showing relationships among categories of knowledge and skills for 2021–2022, Grade 3

Category of knowledge and skills	Knowledge and Understanding	Application	Thinking
Knowledge and Understanding	1.00		
Application	.76	1.00	
Thinking	.66	.72	1.00

For each category of knowledge and skills, achievement across levels displayed a concave growth curve (see Figure 1; the percentages are provided in Table 7). Additionally, some categories of knowledge and skills required somewhat lower numbers of correct responses than others to achieve Level 3. However, the achievement distribution was consistent across categories of knowledge and skills.

Figure 1. Category of knowledge and skills percentage correct range for the middle 50% of Grade 3 students, by achievement level 2021–2022

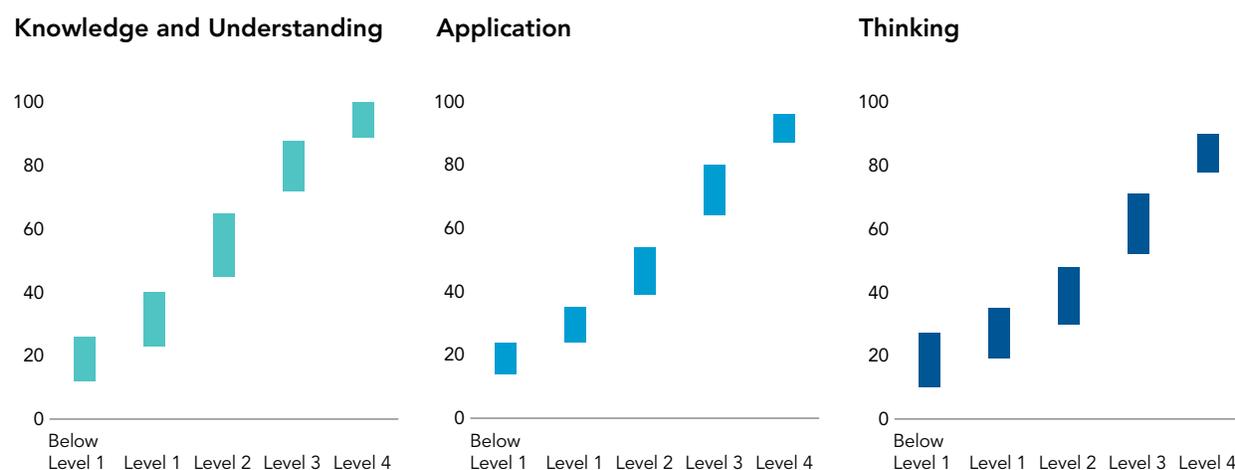


Table 7. Category of knowledge and skills percentage correct range for the middle 50% of Grade 3 students, by achievement level, 2021–2022 (table version of Figure 1)

Category of knowledge and skills	Achievement level				
	Below Level 1	Level 1	Level 2	Level 3	Level 4
Knowledge and Understanding	12 to 26	23 to 40	45 to 65	72 to 88	89 to 100
Application	14 to 24	24 to 35	39 to 54	64 to 80	87 to 96
Thinking	10 to 27	19 to 35	30 to 48	52 to 71	78 to 90

Grade 6

Similar to Grade 3 student achievement, student achievement in Grade 6 was similar across all categories of knowledge and skills (see Figure 2; the percentages are provided in Table 9). That is, students who were at beginning levels of achievement in one category tended to be at beginning levels across all categories. Likewise, students who were at the middle or higher levels of achievement in one category tended to be at middle or higher levels of achievement across all categories. As with Grade 3, some categories required somewhat lower numbers of correct responses than others to achieve Level 3.

These relationships are demonstrated below. As seen in Table 8, the categories of knowledge and skills show strong or very strong relationships.

Table 8. Correlation values showing relationships among categories of knowledge and skills for 2021–2022, Grade 6

Category of knowledge and skills	Knowledge and Understanding	Application	Thinking
Knowledge and Understanding	1.00		
Application	.62	1.00	
Thinking	.55	.75	1.00

The achievement distribution was, as in Grade 3, generally consistent across categories of knowledge and skills (see Figure 2; the percentages are provided in Table 9).

Figure 2. Category of knowledge and skills percentage correct range for the middle 50% of Grade 6 students, by achievement level 2021–2022

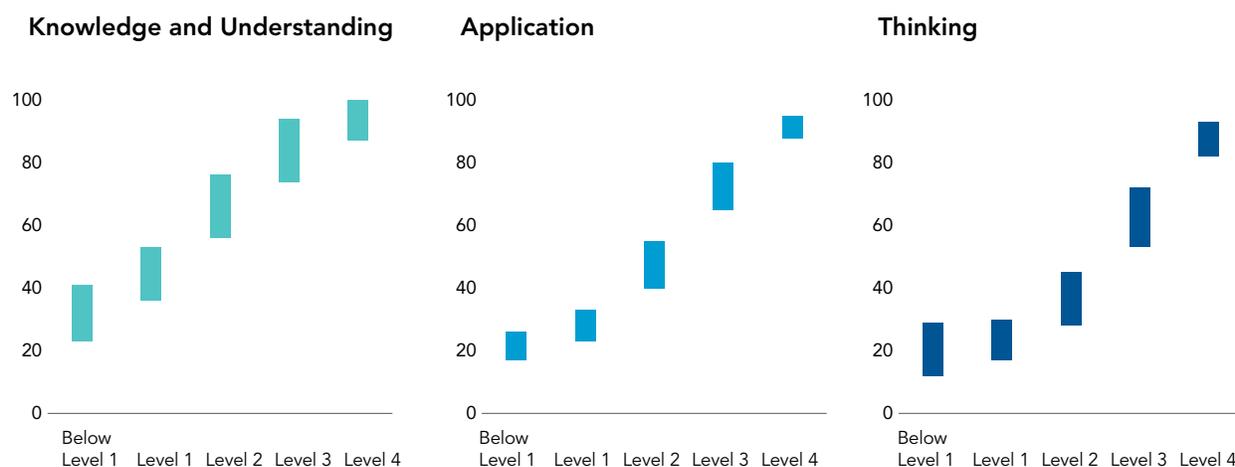


Table 9. Category of knowledge and skills percentage correct range for the middle 50% of Grade 6 students, by achievement level 2021–2022

Category of knowledge and skills	Achievement level				
	Below Level 1	Level 1	Level 2	Level 3	Level 4
Knowledge and Understanding	23 to 41	36 to 53	56 to 76	74 to 94	87 to 100
Application	17 to 26	23 to 33	40 to 55	65 to 80	88 to 95
Thinking	12 to 29	17 to 30	28 to 45	53 to 72	82 to 93

Grade 9

As with Grade 3 and Grade 6 student achievement, student achievement in Grade 9 was mostly consistent across all categories of knowledge and skills. That is, students with lower levels of achievement in one category of knowledge and skills tended to have lower levels across all categories of knowledge and skills. Likewise, students with higher levels of achievement in one category of knowledge and skills tended to have higher levels of achievement across all categories of knowledge and skills. As with Grade 3 and Grade 6, some categories of knowledge and skills required somewhat lower numbers of correct responses than others to achieve Level 3.

These relationships are demonstrated below (see Table 10). As in earlier grades, the categories of knowledge and skills in Grade 9 show strong relationships.

Table 10. Correlation values showing relationships among categories of knowledge and skills for 2021–2022, Grade 9

Math strand / Category of knowledge and skills	Knowledge and Understanding	Application	Thinking
Knowledge and Understanding	1.00		
Application	.68	1.00	
Thinking	.63	.55	1.00

The achievement distribution was, as in Grade 3 and Grade 6, generally consistent across curriculum strands (see Figure 3; the percentages are provided in Table 11).

Figure 3. Category of knowledge and skills percentage correct range for the middle 50% of Grade 9 students, by achievement level 2021–2022

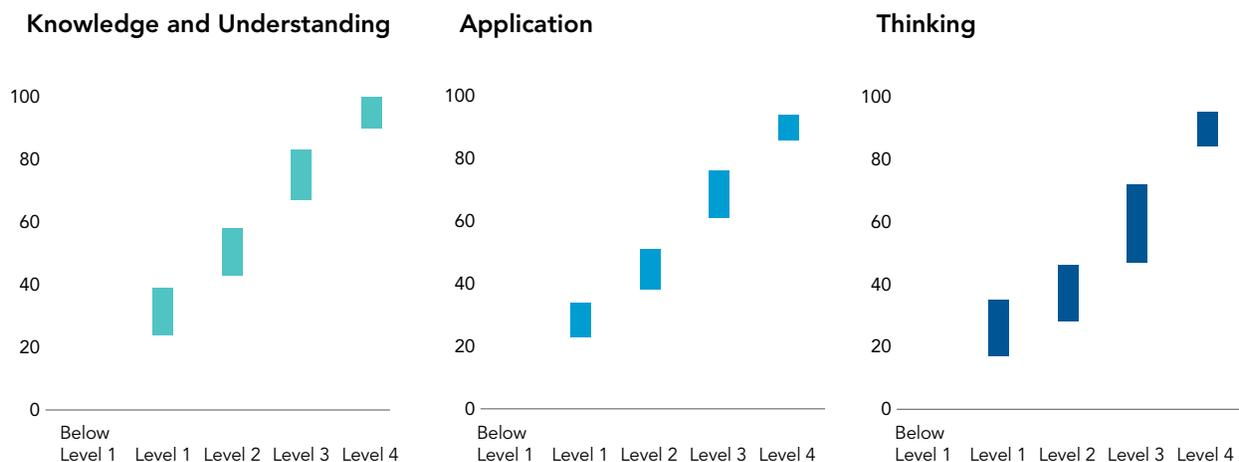


Table 11. Category of knowledge and skills percentage correct range for the middle 50% of Grade 9 students, by achievement level 2021–2022

Category of knowledge and skills	Achievement level				
	Below Level 1	Level 1	Level 2	Level 3	Level 4
Knowledge and Understanding	*NEI	24 to 39	43 to 58	67 to 83	90 to 100
Application	NEI	23 to 34	38 to 51	61 to 76	86 to 94
Thinking	NEI	17 to 35	28 to 46	47 to 72	84 to 95

*NEI = Not enough information to determine a percentage, due to the small number of students at this level.

What was a benchmark result?

The second task in the study was to identify what can be considered a benchmark result for each category of knowledge and skills. The results are reported below for Grade 3, Grade 6 and Grade 9.

Grade 3

Regarding the definition of a benchmark result, the analysis found that when the benchmark score was set at the percent correct achieved by 80% of students who achieved Level 3 (i.e., a clear majority), a clear difference in achievement emerged between Grade 3 students who achieved Level 2 and Grade 3 students who achieved Level 3.

As shown in Table 12, for example, while 80% of students who achieved Level 3 answered 51% or more of Thinking questions correctly, only 19% of students who achieved Level 2 answered this many Thinking questions correctly.

This gap persisted for Knowledge and Understanding, with 80% of students who achieved Level 3 answering 70% or more of Knowledge and Understanding questions correctly, but only 17% of students who achieved Level 2 answered this many Knowledge and Understanding questions correctly.

The largest gap observed was for Application. For this category of knowledge and skills, 80% of students who achieved Level 3 answered 63% or more of Application questions correctly. However, only 6% of students who achieved Level 2 answered this many Application questions correctly.

Table 12. Percentage of Grade 3 students who achieved each benchmark score, by achievement level, 2021–2022

Category of knowledge and skills	Benchmark percent correct	Percentage of students who achieved each benchmark score, by achievement level				
		Below Level 1	Level 1	Level 2	Level 3	Level 4
Knowledge and Understanding	70	0%	<1%	17%	80%	>99%
Application	63	0%	<1%	6%	80%	>99%
Thinking	51	2%	5%	19%	80%	>99%

Grade 6

For Grade 6, the analysis also found that when the benchmark score was set at the percent correct achieved by 80% of students who achieved Level 3 (i.e., a clear majority), a clear difference in achievement emerged between Grade 6 students who achieved Level 2 and those who achieved Level 3. The results are summarized in Table 13.

However, compared to Grade 3, there were differences at Grade 6 in the percentages of Level 2 students achieving the benchmark score. The biggest difference from Grade 3 was for Knowledge and Understanding. In contrast to Grade 3, at Grade 6, 80% of students who achieved Level 3 answered 73% or more of Knowledge and Understanding questions correctly, and 35% of students who achieved Level 2 answered this many Knowledge and Understanding questions correctly. Also somewhat in contrast to Grade 3, 80% of Grade 6 students who achieved Level 3 answered 51% or more of Thinking questions correctly, while only 13% of students who achieved Level 2 answered this many Thinking questions correctly.

The largest gap observed at Grade 6 was for Application, and the gap was almost exactly the same as for Grade 3. For this category of knowledge and skills, 80% of students who achieved Level 3 answered 64% or more of Application questions correctly. However, only 6% of students who achieved Level 2 answered this many Application questions correctly.

Table 13. Percentage of Grade 6 students who achieved each benchmark score, by achievement level, 2021–2022

Category of knowledge and skills	Benchmark percent correct	Percentage of students who achieved each benchmark score, by achievement level				
		Below Level 1	Level 1	Level 2	Level 3	Level 4
Knowledge and Understanding	73	<1%	2%	35%	80%	95%
Application	64	0%	0%	6%	80%	100%
Thinking	51	<1%	1%	13%	80%	100%

Grade 9

At Grade 9, the analysis found, like Grade 3 and Grade 6, that when the benchmark score was set at the percent correct achieved by 80% of students who achieved Level 3 (i.e., a clear majority), a clear difference in achievement emerged between Grade 9 students who achieved Level 2 and Grade 9 students who achieved Level 3. However, compared to Grade 3 and Grade 6, there were different patterns among categories of knowledge and skills in the percentages of students who achieved Level 2 and reached the benchmark score.

Uniquely to Grade 9, a substantial overlap was observed for Thinking. For example, 80% of students who achieved Level 3 answered 46% or more of Thinking questions correctly. Among students who achieved Level 2, 31% of students met this benchmark score. Also uniquely to Grade 9, a large gap was observed between students who achieved Level 3 and students who achieved Level 2 for Knowledge and Understanding. Whereas 80% of students who achieved Level 3 answered 65% or more of these questions correctly, only 11% of students who achieved Level 2 met this benchmark score for Knowledge and Understanding.

Finally, consistent with Grade 3 and Grade 6, the largest difference between students who achieved Level 3 and Level 2 was observed for Application. While 80% of students who achieved Level 3 answered 59% of more of Application questions correctly, only 7% of students who achieved Level 2 met this benchmark score. Table 14 shows these findings.

Table 14. Percentage of Grade 9 students who achieved each benchmark score, by achievement level, 2021–2022

Category of knowledge and skills	Benchmark percent correct	Percentage of students who achieved each benchmark score, by achievement level				
		Below Level 1	Level 1	Level 2	Level 3	Level 4
Knowledge and Understanding	65	NEI	<1%	11%	80%	100%
Application	59	NEI	<1%	7%	80%	100%
Thinking	46	NEI	14%	31%	80%	100%

Achievement profiles

A third goal of the study was to understand whether there were patterns in achievement profiles. For example, did students who achieved the benchmark score in Knowledge and Understanding also typically achieve the benchmark scores for other categories of knowledge and skills? How many benchmark scores needed to be met in order for students to have a good chance of achieving Level 3?

Grade 3

An analysis of Grade 3 students' achievement profiles showed that students who achieved Level 3 were very likely to achieve two or three of the benchmark scores, while students who achieved Level 2 were very unlikely to achieve two or three benchmark scores (see Table 15). For example, 63% of students who achieved Level 2 failed to achieve any benchmark scores for categories of knowledge and skills, and 33% of students who achieved Level 2 achieved only one benchmark score. Meanwhile, only 5% of students who achieved Level 2 also achieved two or three benchmark scores in the categories of knowledge and skills.

In contrast, only 14% of students who achieved Level 3 failed to achieve any curriculum strand benchmark scores or achieved only one. Meanwhile, 32% of students who achieved Level 3 also achieved two benchmark scores, and 54% of students who achieved Level 3 achieved all three benchmark scores.

Table 15. Percentage of Grade 3 students who achieved each number of benchmark scores, by achievement level, 2021–2022

Number of categories of knowledge and skills benchmark scores achieved	Percentage of students who achieved each number of benchmark scores, by achievement level				
	Below Level 1	Level 1	Level 2	Level 3	Level 4
No categories	98%	95%	63%	1%	
1 category	2%	5%	33%	13%	
2 categories			5%	32%	<1%
3 categories			<1%	54%	>99%

Grade 6

An analysis of Grade 6 students' achievement profiles showed that students who achieved Level 3 were very likely to achieve two or three of the benchmark scores, while students who achieved Level 2 were very unlikely to achieve two or three benchmark scores (see Table 16). For example, 54% of students who achieved Level 2 failed to achieve any benchmark scores for categories of knowledge and skills, and 38% of students who achieved Level 2 achieved only one benchmark score. Meanwhile, only 7% of students who achieved Level 2 also achieved two or three category of knowledge and understanding benchmark scores.

In contrast, only 11% of students who achieved Level 3 failed to achieve any curriculum strand benchmark scores or achieved only one. Meanwhile, 36% of students who achieved Level 3 also achieved two benchmark scores, and 53% of students who achieved Level 3 achieved all three benchmark scores.

Table 16. Percentage of Grade 6 students who achieved each number of benchmark scores, by achievement level, 2021–2022

Number of categories of knowledge and skills benchmark scores achieved	Percentage of students who achieved each number of benchmark scores, by achievement level				
	Below Level 1	Level 1	Level 2	Level 3	Level 4
No categories	99%	97%	54%	<1%	
1 category	1%	3%	38%	11%	
2 categories			7%	36%	5%
3 categories			<1%	53%	95%

Grade 9

Finally, an analysis of Grade 9 students' achievement profiles similarly showed that students who achieved Level 3 were also very likely to achieve two or three of the benchmark scores, while students who achieved Level 2 were very unlikely to do so (see Table 17). For example, 56% of students who achieved Level 2 failed to achieve any benchmark scores for categories of knowledge and skills, and 39% of students who achieved Level 2 achieved only one benchmark score. Meanwhile, only 5% of students who achieved Level 2 also achieved two or three category of knowledge and understanding benchmark scores.

In contrast, only 13% of students who achieved Level 3 failed to achieve any curriculum strand benchmark scores or achieved only one. Meanwhile, 31% of students who achieved Level 3 also achieved two benchmark scores, and 56% of students who achieved Level 3 achieved all three benchmark scores.

Table 17. Percentage of Grade 9 students who achieved each number of benchmark scores, by achievement level, 2021–2022

Number of categories of knowledge and skills benchmark scores achieved	Percentage of students who achieved each number of benchmark scores, by achievement level				
	Below Level 1	Level 1	Level 2	Level 3	Level 4
No categories	NEI	85%	56%	1%	
1 category	NEI	15%	39%	12%	
2 categories	NEI		5%	31%	
3 categories	NEI		<1%	56%	100%

DISCUSSION

Connectedness of categories of knowledge and skills

The analysis findings for achievement patterns and achievement profiles clearly show that at Grades 3, 6 and 9, as achievement increases, achievement in all categories of knowledge and skills rises at approximately the same rate. Therefore, the conclusion is that achievement among the mathematics categories of knowledge and skills is highly connected, that the skills build on each other and that improving math achievement requires attention to all categories of knowledge and skills. The instructional approach of spiralling is one that increases math achievement through attention to all categories of knowledge and skills (Ontario Ministry of Education, 2020b).

A benchmark result

The following is a summary of the study findings regarding the definition of a benchmark result:

To have a good chance of achieving a Level 3 in math in Grade 3 (in 2021–2022), students needed two out of three of the scores below:

- At least 70% in Knowledge and Understanding
- At least 63% in Application
- At least 51% in Thinking

For Grade 6 math, students needed two out of three of the scores below:

- At least 73% in Knowledge and Understanding
- At least 64% in Application
- At least 51% in Thinking

Finally, for Grade 9 math, students needed two out of three of the scores below:

- At least 65% in Knowledge and Understanding
- At least 59% in Application
- At least 46% in Thinking

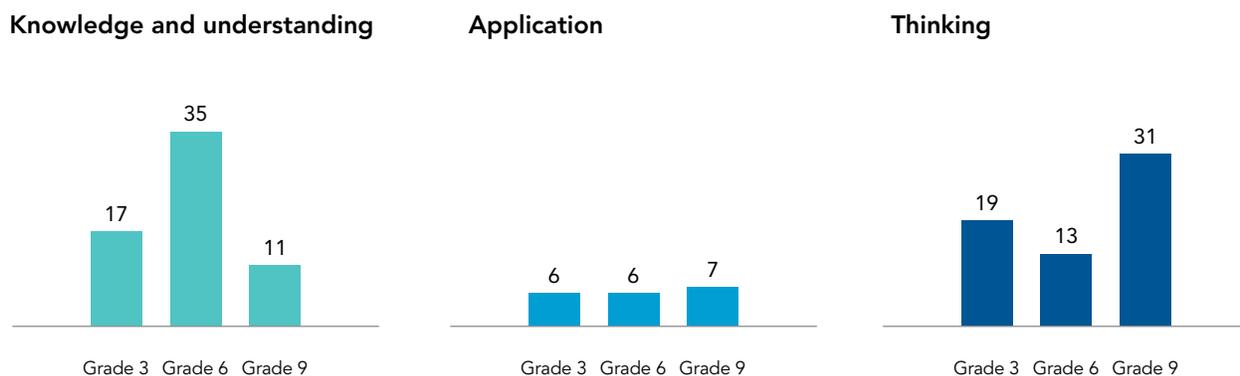
It is worth emphasizing that student achievement across the categories of knowledge and skills was reasonably similar for a given EQAO level. However, the analysis results above achieve the goal of defining a 2021–2022 benchmark result in terms of percentage of questions correct.

Differences in achievement of benchmark scores, by EQAO level achieved

The analyses demonstrated that there were clear differences in the percentage of students who achieved Level 2 and also reached benchmark scores and students who achieved Level 3. It appears that a smaller overlap between the two groups for a category of knowledge and skills—that is, a lower percentage of students who achieved Level 2 who also met the benchmark score for that category—means the category contributes more strongly to meeting the overall curriculum expectations. This phenomenon is likely related to the number of questions devoted to a given category of knowledge and skills, reflecting its importance in meeting curriculum expectations.

Figure 4 shows, for each grade and category of knowledge and skills, the percentage of students who achieved Level 2 who also achieved each category’s benchmark score. Recall that among students who achieved Level 3, 80% of students achieved each benchmark score.

Figure 4. Percentage of students who achieved Level 2 who achieved the benchmark score for each category of knowledge and skills, by grade 2021–2022



Critical role of Application

Due to the differences in achievement of benchmark scores, the study yielded the observation that the Application category of knowledge and skills appears to play a critical role in math achievement at Grade 3, Grade 6 and Grade 9. This conclusion was drawn due to the observation that most students who achieved Level 3 at any grade achieved the benchmark score for Application (80%), while very few students who achieved Level 2 demonstrated that level of mastery in Application (only 6–7%). It is also worth highlighting that 44% of questions on the Grade 3 assessment, 49% of questions on the Grade 6 assessment and 34% of questions on the Grade 9 assessment use the Application category of knowledge and skills. This likely increased the clarity with which students achieving Level 2 and Level 3 were identified for that category. Thus, it is clear that the Application category of knowledge and skills plays a foundational role in mathematics achievement.

Roles of Knowledge and Understanding and Thinking

The categories Knowledge and Understanding, and Thinking, displayed different trends. For Grade 3 students, both Knowledge and Understanding, and Thinking, appeared to be fairly important for demonstrating mastery of math curriculum content. For example, 17% of students who achieved Level 2 met the same benchmark score for Knowledge and Understanding that was met by 80% of students who achieved Level 3. Likewise, 19% of students who achieved Level 2 met the same benchmark score for Thinking that was met by 80% of students who achieved Level 3.

However at Grade 6 and Grade 9, the trends differed. At Grade 6, 35% of students who achieved Level 2 met the same benchmark score for Knowledge and Understanding that was met by 80% of students who achieved Level 3. In contrast, 13% of students who achieved Level 2 met the same benchmark score for Thinking that was met by 80% of students who achieved Level 3. Grade 9 showed the reverse pattern. Only 11% of Grade 9 students who achieved Level 2 met the same benchmark score for Knowledge and Understanding that was met by 80% of Grade 9 students who achieved Level 3. However, 31% of Grade 9 students who achieved Level 2 met the same benchmark score for Thinking that was met by 80% of Grade 9 students who achieved Level 3.

These results indicate that mastery of grade-level Thinking skills may be more important to being able to meet curriculum expectations at Grade 6, whereas mastery of grade-level Knowledge and Understanding is more important at Grade 9. One explanation for this difference is that the Grade 6 curriculum may emphasize the application of more advanced thinking about the skills accumulated from junior kindergarten through Grade 6. In contrast, the Grade 9 curriculum may emphasize demonstration of Knowledge and Understanding that forms the foundation of the high school math curriculum. This would reflect *The Ontario Curriculum, Grades 1–8: Mathematics, 2020* (p.72), which specifically discusses how the curriculum is designed to foster progressive skills development across grades:

“The specific expectations reflect this progression in knowledge and skill development through changes in the wordings of the expectations and through the introduction of new expectations, where appropriate. The progression is captured by the increasing complexity of the pedagogical supports... associated with most expectations and by the increasing specificity of mathematical relationships, the diversity of contexts in which the learning is applied, and the variety of opportunities presented for applying it. It should be noted that all the skills specified in the early grades continue to be developed and refined as students move through the grades, whether or not each of those skills continues to be explicitly required in an expectation.”

CONSIDERATIONS FOR INSTRUCTIONAL PLANNING

The findings of this study indicate that it is essential to address math ability across all categories of knowledge and skills, as mathematical thinking and skills differ somewhat across categories but are in fact also highly connected across categories. The importance of the integration of categories is reflected in the provincial report cards for Grades 1 to 8, where students receive one overall mark for mathematics. Teachers therefore have the option to integrate categories of knowledge and skills through a planning model that permits them to spiral through different concepts and categories in the classroom throughout the school year.

In this way, teachers can gradually and systematically introduce more complex and rigorous tasks, and the progression of learning will become more complex both as the school year progresses and from grade to grade (Ministry of Education, 2020a, pp. 71–72; Pashler et al., 2007). Such an approach can be utilized alongside other instructional strategies such as direct instruction, teaching about problem solving and deliberate practice (Ontario Ministry of Education, 2020b, p. 50), and positively impact student learning.

That said, students' progress (or lack thereof) in key categories of knowledge and skills at specific grade levels may flag students at risk of falling behind curriculum expectations. For example, according to the analyses in this study, Application skills appear critical to meeting grade expectations throughout school. In addition, at Grade 6 Thinking skills also appear very important. Finally, at Grade 9 Knowledge and Understanding at grade level seems very important.

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