EQAO

Student Achievement on Mathematics Categories of Knowledge and Skills, 2021–2022

Research Brief

OCTOBER 2023

What are Ontario students' strengths and needs in mathematics? How does achievement on the Ontario curriculum's categories of knowledge and skills in mathematics relate to meeting overall curriculum expectations?[1] EQAO took a look at these questions using the 2021–2022 results on mathematics categories for Grade 3, Grade 6 and Grade 9 students across Ontario.

To explore these questions, the following analytic strategies were used:[2]

1. The average percentage correct for each category of knowledge and skills was calculated for each grade.
2. The correlations between percentage correct scores for each category were calculated for each grade.
3. A "benchmark" percentage correct for each category was set for each grade. The benchmark percentage correct was the score achieved by 80% of students who achieved Level 3, the provincial standard for achievement. Readers can think of the benchmark percentage correct as the minimum score a student needs to have a good chance of meeting provincial expectations.[3]
4. The percentage of students who achieved Level 2 (approaching the provincial standard) **and** achieved the benchmark percentage correct was calculated for each category and grade.

[1] Four categories of knowledge and skills are described in Ontario curricula, three of which are assessed on EQAO mathematics assessments. The Ministry definitions of the categories are as follows: Knowledge and Understanding: "Subject-specific content acquired in each grade or course (knowledge), and the comprehension of its meaning and significance (understanding)." Application: "The use of knowledge and skills to make connections within and between various contexts." Thinking: "The use of critical and creative thinking skills and/or processes." The category not explicitly assessed is Communication: "The conveying of meaning and expression through various forms." (Ontario Ministry of Education, 2020, p.50). EQAO has adapted the definitions of the three categories from the achievement chart for mathematics found in the Ontario mathematics curriculum. A question is mapped to the category Knowledge and Understanding if in order to answer the question, students must demonstrate only subject-specific content (knowledge) and/or comprehension of its meaning and significance (understanding). A question is mapped to the category Application if in order to answer the question, students must either select the appropriate tool or get the necessary information and "fit" it to the problem. A question is mapped to the category Thinking if in order to answer the question, students must either select and sequence a variety of tools or demonstrate a critical thinking process (e.g., reasoning).

[2] Reference full research report to see results (EQAO, 2023).

[3] The technical term for this score is the 20th percentile score. The 20th percentile was chosen because it is a quantified way of saying "a large majority of students who achieved Level 3 can achieve this percentage correct."

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 dataset included 126 660 Grade 3 students, 130 711 Grade 6 students and 72 616 Grade 9 students.[4] Student scores from English-language and French-language boards were analyzed together, because there were no meaningful differences in the results between the populations.[5]

Average achievement on mathematics categories of knowledge and skills

Looking at the average achievement on each category of knowledge and skills gives us an idea of how many questions students answer correctly on average.[6] Table 1 shows the average achievement for each category and grade. Results show, for example, that at each grade level, students answer fewer questions correctly on average in the Thinking category than they do in the Application or Knowledge and Understanding categories.

Table 1. Average percent correct for all students, by category of knowledge and skills and grade

Category	Grade 3	Grade 6	Grade 9
Knowledge and Understanding	69.6	73.1	62.9
Application	62.6	59.4	56.7
Thinking	54.3	49.5	49.4
Number of students	126 660	130 711	72 616

Mathematics learning overflows across the categories of knowledge and skills

In addition, an important finding was that students answering many questions correctly in one category usually also answered many questions correctly in other categories. For example, Figure 1 shows that, although the exact numbers vary, Grade 3 students who answered many questions correctly on the Knowledge and Understanding category also answered more questions correctly than other students in Application and Thinking.

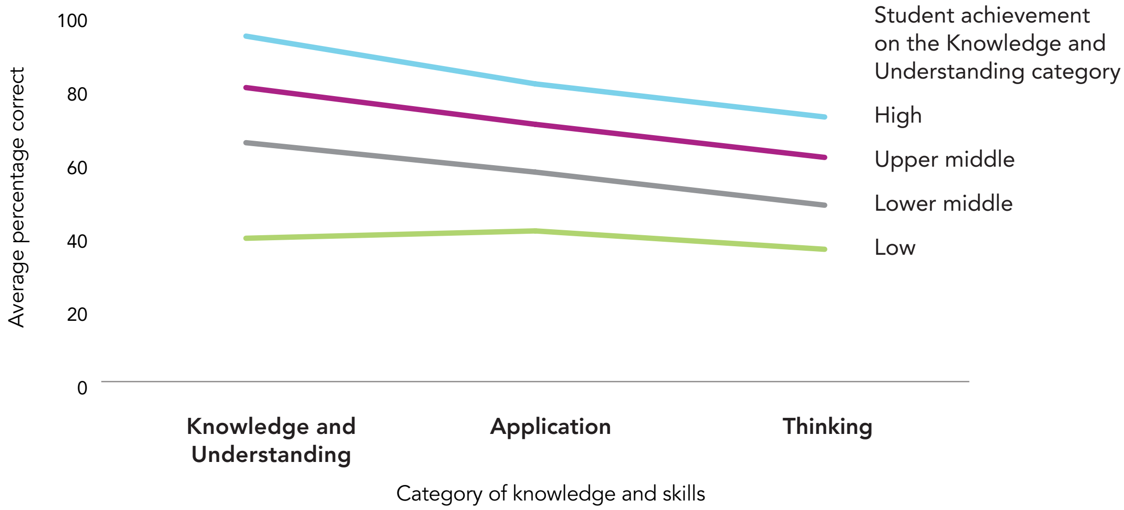
This finding makes clear that achievement among the categories is highly connected, meaning that student ability in one category "overflows" and makes it easier to develop knowledge and skills from other categories. We might ask, however, whether one category exerts more influence than others? For example, does it matter whether equal attention is given to all categories of knowledge and skills, or should some categories receive more learning time?

[4] 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, so this cohort size is smaller than in previous and subsequent years.

[5] Student scores from English-language and French-language boards were initially analyzed separately, but the results presented in this research brief were the same for all categories of knowledge and skills.

[6] The percentage correct across categories of knowledge and skills cannot be compared as evidence that students have achieved higher or lower in a particular category, because the assessments are not designed to contain questions of the same difficulties for each category. For example, while Grade 9 students on average answered 63% of Knowledge and Understanding questions correctly and 49% of Thinking questions correctly, it could just be that the Knowledge and Understanding category had some easier questions than the Thinking category. As a result, for students to meet provincial expectations, we should also not expect the same percentage correct to be required for all categories of knowledge and skills.

Figure 1. Average percentage correct on each category of knowledge and skills, among four groups of Grade 3 students



Some categories appear to exert more influence than others

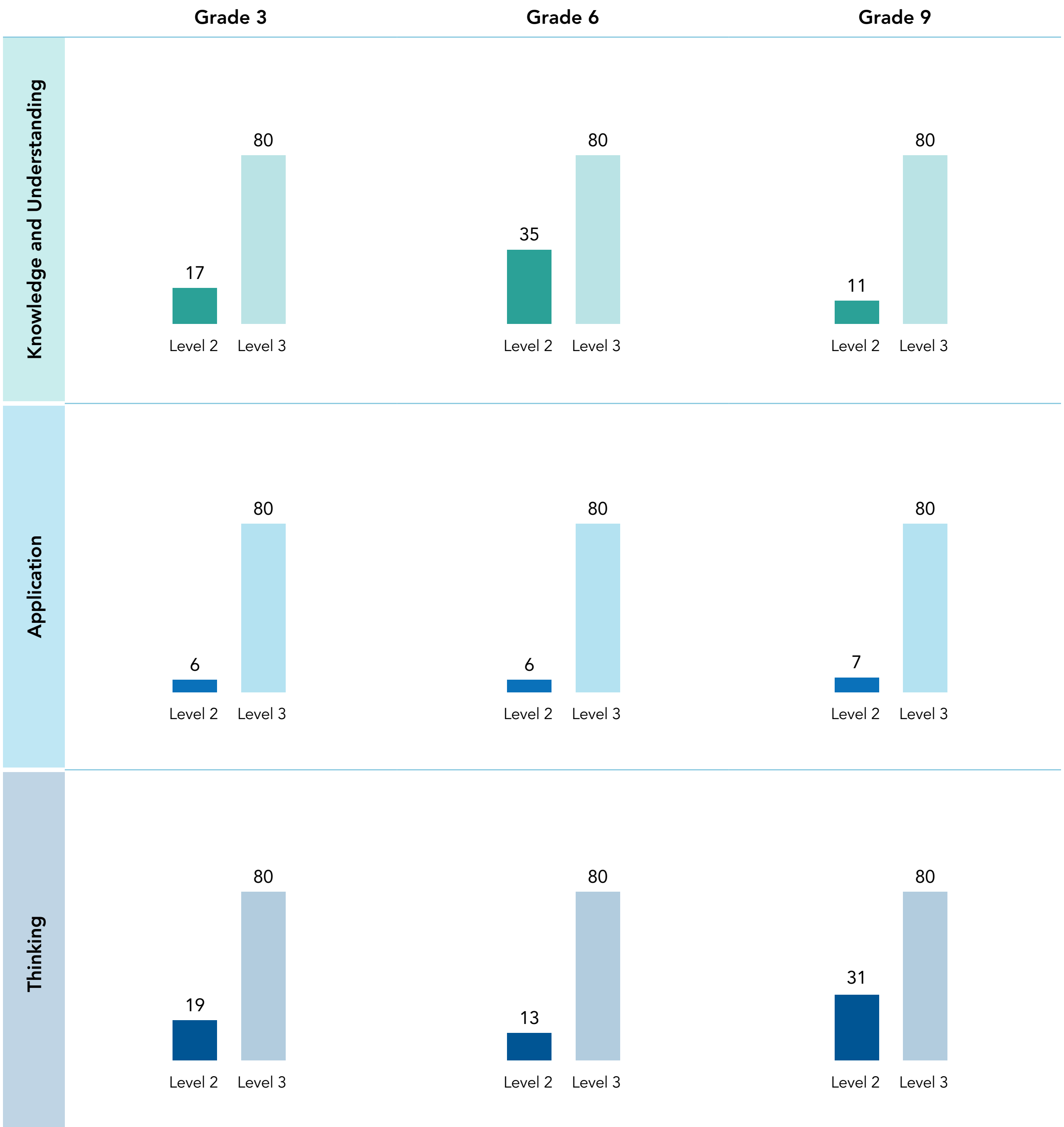
We introduced the benchmark percentage correct on page 1. Remember, 80% of students who achieved Level 3 achieved this percentage. Let's now look at the percentage of students who achieved Level 2 and achieved the benchmark percentage correct for each category of knowledge and skills. The findings, shown in Figure 2, are striking. For example,

- only 17% of students in Grade 3 who achieved Level 2 also achieved the benchmark percentage correct (i.e., the percentage that 80% of students at Level 3 obtained) for the Knowledge and Understanding category of knowledge and skills.
- in Grade 6, 35% of these students achieved this percentage.
- in Grade 9, the percentage was down to 11% of students.

At the same time, within each grade, the categories show different patterns for these percentages. Looking at these patterns, backed up with a review of curriculum content and the number of assessment questions devoted to each category, we see that some categories appear to exert more influence than others in certain grades.[7]

[7] Percentage of all available questions requiring the Knowledge and Understanding category of knowledge and skills: Grade 3: 31%; Grade 6: 24%; Grade 9: 37%. Percentage of questions requiring the Application category of knowledge and skills: Grade 3: 44%; Grade 6: 49%; Grade 9: 34%. Percentage of questions requiring the Thinking category of knowledge and skills: Grade 3: 25%; Grade 6: 27%; Grade 9: 29%.

Figure 2. Percentage of students who achieved the 'benchmark' percentage correct for each category of knowledge and skills, by achievement level



Which categories of knowledge and skills relate most closely to meeting overall curriculum expectations?

Application is critical at all grade levels.
Firstly, the Application category of knowledge and skills appears to play a critical role in math achievement at Grades 3, 6 and 9. For example, in all grades, only 6–7% of students who achieved Level 2 also achieved the benchmark percentage correct for Application.

A review of curriculum content shows that the majority of expectations across all strands and grades do indeed encourage the Application category of knowledge and skills to be taught.

Thinking is key in Grade 6.
Secondly, the Thinking category of knowledge and skills appears to take a central role in Grade 6 (and not, as might be expected, in Grade 9). For example, in Grade 6, only 13% of students who achieved Level 2 met the benchmark percentage correct. In contrast, at Grade 9, 31% of students who achieved Level 2 met the benchmark percentage correct, which shows that many students who were not yet meeting overall expectations were able to demonstrate sufficient proficiency in the Thinking category of knowledge and skills.

A review of curriculum content offers an explanation: there are expectations in the Grade 6 curriculum that build on skills and knowledge that have been developing since Grade 1. For example, foundational knowledge of fraction representations and notation that is layered during Grades 1 to 3 is assumed knowledge for Grade 6 problem solving—and problem solving requires the use of Application and Thinking skill sets.

Knowledge and Understanding is key in Grade 9.
Somewhat counterintuitively, as students progress in math studies, there appears to be a return to the importance of Knowledge and Understanding skills in Grade 9. For example, in Grade 6, 35% of students who achieved Level 2 were able to meet the benchmark percentage correct, reflecting the emphasis on Thinking knowledge and skills in Grade 6. However, by Grade 9, only 11% of students who achieved Level 2 achieved the benchmark percentage correct for Knowledge and Understanding.

However, a review of the Grade 9 curriculum reveals the reason for this finding. It appears that the Grade 9 curriculum emphasizes the Knowledge and Understanding and Application categories to form a foundation for the advanced math topics covered in Grades 10, 11 and 12. For example, the Grade 9 expectation C3.1 requires students to know a variety of ways to determine when mathematical models are linear or not, and if they are linear to determine the rate of change and other characteristics of the line. Expectation C3.2 addresses linear relationships with concrete materials, tables of values, graphics and equations.

The knowledge and skills learned from these two expectations are further developed in the Grade 10 curriculum in both applied and academic courses. In these courses, the same type of exploration occurs with quadratic relations. This progression gives students the opportunity to use and expand their initial knowledge and understanding of linear relationships and defining characteristics, and learn how those defining characteristics behave in similar ways across different types of functions as the students progress through Grade 10 and beyond.

Implications for teaching

These findings show that it is essential to address all categories of knowledge and skills, as mathematical thinking and skills are highly connected. For this reason, the curriculum requires all categories of knowledge and skills to be taught across curriculum strands.

In addition, the findings imply that, while all categories of knowledge and skills need to be taught at all grades, the following strategies are important for student success:

- In Grades 1 to 3, ensure that integration of categories of knowledge and skills positions Application as a critical category of knowledge and skills, although Knowledge and Understanding, and Thinking take up almost equal weight at these early stages of learning.
- In Grades 4 to 6, treat the Application and Thinking categories of knowledge and skills as particularly necessary to set up students for success as they build on and extend the foundational concepts they learnt in kindergarten and the primary grades.
- In Grades 7 to 9, treat the Knowledge and Understanding and Application categories of knowledge and skills as particularly necessary to set up students for success as they prepare to take on advanced mathematics topics in Grade 10 and beyond.

References

EQAO. (2023). *Student achievement on mathematics categories of knowledge and skills: Results from the 2021–2022 Grades 3, 6 and 9 assessments*. King's Printer for Ontario.

Ontario Ministry of Education. (2020). The Ontario Curriculum, Grades 1–8: Mathematics 2020. https://www.dcp.edu.gov.on.ca/en/curriculum/elementary-mathematics