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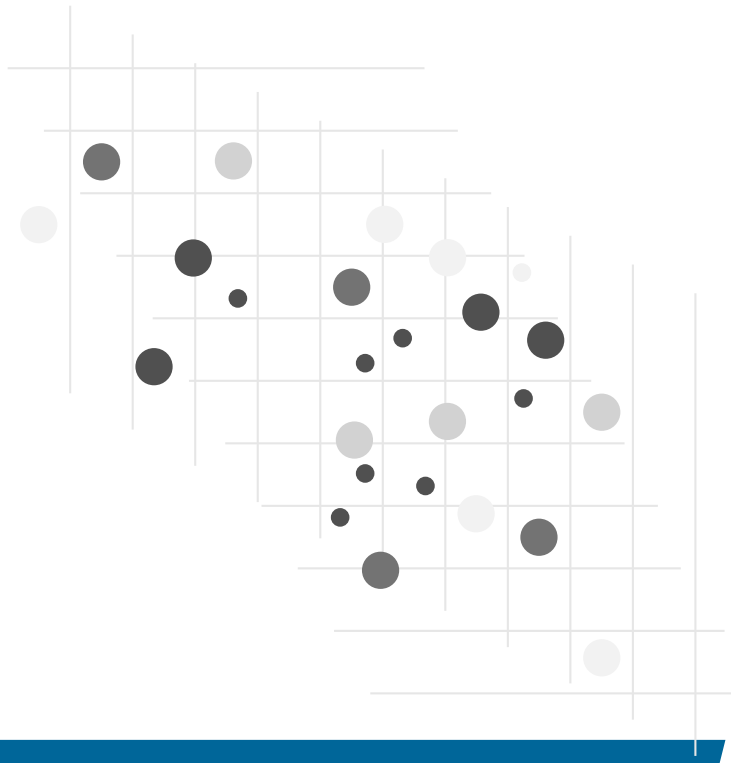
Mathematics in context: students' attitudes towards mathematics and their experiences of the mathematics classroom in PISA 2022

Brendan O'Neill, Aidan Clerkin, Rachel Perkins, Kervin Soobrayen



PISA Research Series

Document Number ERC-2026-01, April 2026

www.erc.ie

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23 April 2026

Document Number ERC-2026-01

Available to download from www.erc.ie

DOI: https://doi.org/10.70092/1691813.0126

ISBN: 978-1-911678-38-0 (PDF)

How to cite this report:
O'Neill, B., Clerkin, A., Perkins, R., Soobrayen, K. (2026). *Mathematics in context: students' attitudes towards mathematics and their experiences of the mathematics classroom in PISA 2022*. Educational Research Centre. ERC-2026-01. https://doi.org/10.70092/1691813.0126

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The ERC carries out research at all levels of the education system. Research is undertaken on behalf of the Department of Education, at the request of other agencies and on the initiative of the ERC itself and its staff.

The ERC provides an assessment support service to schools, supplying a range of standardised tests to primary and post-primary schools. The *ERC Drumcondra tests* are the leading standardised tests used in Irish schools.

The ERC also publishes the Irish Journal of Education.

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Acknowledgements

The authors would like to take this opportunity to thank all the staff at the Educational Research Centre (ERC) who supported the project throughout the preparation, testing, and reporting phases. In particular, we are deeply grateful to the PISA 2022 team for collecting such valuable data. We also extend our thanks to current CEO John Regan, former CEOs Aidan Clerkin and Jude Cosgrove, the Administration and IT teams within the Centre, and the temporary staff members who contributed during the field trial and main study phases.

We would also like to acknowledge the invaluable contributions of members of the Department of Education and Youth's Inspectorate, along with temporary staff who served as test administrators in schools during testing, and the external PISA Quality Monitors. We also appreciate the support of those who provided laptop rental, technical assistance, and translation services. Our sincere gratitude goes to the current and former members of the PISA National Advisory Committee (see Appendix A) for their guidance, insight, and support throughout the preparation, administration, and reporting of the 2022 cycle.

Finally, and most importantly, we wish to thank everyone who took part in PISA 2022. Particular thanks are due to the School Contacts and Principals who dedicated their time and effort to facilitate PISA testing within schools, and to the students, parents and teachers who participated in the study.

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Acronyms and Abbreviations

DES	Department of Education and Skills
DEY	Department of Education and Youth
ERC	Educational Research Centre
EU	European Union
ICT	Information and communication technology
MSAT	Multi-stage adaptive testing
NCCA	National Council for Curriculum and Assessment
NRBA	Non-response bias analysis
OECD	Organisation for Economic Cooperation and Development
PISA	Programme for International Student Assessment
SEC	State Examinations Commission
STEM	Science, Technology, Engineering, and Mathematics
TIMSS	Trends in International Mathematics and Science Study

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1. Introduction

1.1. PISA 2022 in Ireland

The Programme for International Student Assessment (PISA) is a study run by the Organisation for Economic Cooperation and Development (OECD). It has been carried out every three years since 2000, with the exception of PISA 2022, which was delayed by one year due to the Covid-19 pandemic. PISA measures the performance of 15-year-old students in mathematics, reading and science with a focus on real world applications of skills in these subjects. A total of 81 countries/economies participated in PISA in 2022 as outlined in Table 1.1.

Ireland's participation in PISA is managed by the Educational Research Centre (ERC) on behalf of the Department of Education and Youth (DEY), and overseen by a National Advisory Committee comprising representatives from the DEY, the National Council for Curriculum and Assessment (NCCA), the State Examinations Commission (SEC), and subject-matter experts in each of the domains (see Appendix A for details on membership of the committee).

PISA 2022 was conducted in Ireland between October and early December 2022. This was a change from the spring administration that had occurred in previous cycles of PISA in Ireland (Denner et al., 2025). A total of 170 schools took part in PISA 2022 in Ireland, equivalent to a weighted school response rate of 100%. In each of the participating schools, up to 46 eligible students were randomly selected. Of those selected, 5,569 students took part resulting in a weighted student response rate of 76.8%. According to the PISA technical standards, a final weighted student response rate of 80% is required. As the required response rate in Ireland was below this threshold a non-response bias analysis (NRBA) was conducted. The outcome of this analysis suggested that there was a slight upward bias in the PISA 2022 achievement estimates for Ireland, indicating that these estimates may have been slightly lower if all sampled students had participated (Donohue et al, 2023a). It should be noted that a greater number of countries/economies had difficulties meeting the response thresholds in 2022 than in previous cycles. All other technical standards were met in Ireland.

Table 1.1 - Countries/economies participating in PISA 2022

OECD Countries		Partner Countries/Economies	
Australia	Lithuania	Albania	Malta
Austria	Mexico	Argentina	Moldova
Belgium	Netherlands	Baku (Azerbaijan)	Mongolia
Canada	New Zealand	Brazil	Montenegro
Chile	Norway	Brunei Darussalam	Morocco
Colombia	Poland	Bulgaria	North Macedonian
Costa Rica	Portugal	Cambodia	Palestinian Authority
Czech Republic	Slovak Republic	Chinese Taipei	Panama
Denmark	Slovenia	Croatia	Paraguay
Estonia	Spain	Cyprus	Peru
Finland	Sweden	Dominican Republic	Philippines
France	Switzerland	El Salvador	Qatar
Germany	Turkey	Georgia	Romania
Greece	United Kingdom	Guatemala	Saudi Arabia
Hungary	United States	Hong Kong (China)	Serbia
Iceland		Indonesia	Singapore
Ireland		Jamaica	Thailand
Israel		Jordan	Ukrainian regions (18 of 27)
Italy		Kazakhstan	United Arab Emirates
Japan		Kosovo	Uruguay
Korea		Macau (China)	Uzbekistan
Latvia		Malaysia	Viet Nam

Source: OECD, 2023a

As PISA is an age-based sample[1] rather than a grade-based sample, the move to autumn testing in PISA 2022 meant that the distribution of the sample across academic grades was different than in previous PISA cycles in Ireland. The majority of students in the PISA 2022 sample were in Transition Year (57.0%) at the time of assessment (see breakdown in Table 1.2). In contrast, the majority of students (over 60%) in the PISA 2018 sample in Ireland were in Third Year at the time of the assessment. The gender breakdown of participating students in PISA 2022 in Ireland was 48.7% female and 51.3% male (weighted percentages). The distribution of the student sample across different school types is also outlined in Table 1.2. Twenty-one percent of students in the achieved sample attended a DEIS school.

Table 1.2 - Percentages of students by grade and school sector and gender composition in PISA 2022

School Grade	%	School Sector	%
First and Second Year	0.2	Girls Secondary	17.8
Third Year	26.1	Boys Secondary	16.5
Transition Year	57.0	Mixed Secondary	19.1
Fifth Year	16.2	Community/Comprehensive	16.2
Sixth Year	0.5	Vocational (ETB)	30.4

Source: Donohue et al., 2023b

The test consisted of a two-hour computer-based assessment of mathematics, reading and science, followed by student questionnaires taking approximately 55 minutes to complete. In every cycle of PISA, one of the three core subjects in turn is the major domain, and the other two subjects are minor domains. Mathematics was the major domain in PISA 2022, having previously been the major domain in PISA 2012 and PISA 2003. There is more testing time allocated to the major domain, and the bank of test items as well as the assessment framework for that domain are updated in that particular cycle. This also allows for the introduction of new formats

[1] The PISA target population is students between 15 years and three (completed) months and 16 years and two (completed) months at the beginning of the testing period (Standard 1.1; PISA Technical Standards, OECD, 2020). In Ireland, this meant that the sample of students was drawn from the population of students born between 1st August 2006 and 31st July 2007.

focused on interactivity, thereby exploiting advantages offered by computer-based assessment (PISA 2012 was administered as a paper-based assessment in all countries).

The PISA 2022 mathematics framework (OECD, 2023b) highlights the relevance of mathematics to students, underpinning the development of items set in relatable, real-word contexts. In recognition of the increasing importance of digital devices since the development of the previous mathematics framework in 2012, the 2022 framework emphasises that students should be able to apply computational thinking skills in solving certain mathematics problems. It sets out the definition of mathematical literacy as follows:

> Mathematical literacy is an individual's capacity to reason mathematically and to formulate, employ, and interpret mathematics to solve problems in a variety of real-world contexts. It includes concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to know the role that mathematics plays in the world and to make the well-founded judgements and decisions needed by constructive, engaged and reflective 21st Century citizens. (p. 22)

As well as defining mathematical literacy, and the real-world contexts in which this will be called upon, the framework sets out the organisation of the mathematics domain into four cognitive processes (formulating; employing; interpreting; reasoning), and four content areas (change and relationships; space and shape; quantity; uncertainty and data).

The greater number of items included in the assessment for the major domain allows for the assessment of achievement across the various cognitive processes and content areas. This includes a reasoning subscale for the first time, recognising the increased emphasis on this cognitive process in the PISA 2022 mathematics framework. More detail on the cognitive processes and content areas, including student performance, are outlined in Chapter 2.

The framework also sets out the structure of the mathematics assessment. Throughout the assessment the test questions are grouped into units covering different stimulus materials. These materials can include, for example, texts, charts, illustrations, graphs or spreadsheets, with a set of multiple choice and open-

response questions, or items, about that material. PISA employs multi-stage adaptive testing (MSAT). Under this hybrid testing model, a quarter of students are randomly allocated to a medium-difficulty linear pathway. The remainder of students follow adaptive pathways based on their responses to previous questions as they progress through the assessment. What this means in practice is that the level of difficulty of subsequent units presented to these students is influenced by their performance on preceding units. This tailors the level of difficulty of the items that these students answer and allows for more accurate assessment of students' abilities, particularly at higher and lower levels of proficiency.

The Student Questionnaire was also computer-based and completed directly after the cognitive assessment. This questionnaire gathered information from students on characteristics of their home and family life, as well as their attitudes to learning, learning behaviours and perceptions of school and teaching. This was supplemented by optional short questionnaires on Information and communication technology (ICT) and well-being, with Ireland choosing to administer these optional questionnaires. School principals were also asked to complete an online questionnaire focused on the characteristics and practices of their school. A nationally developed questionnaire for mathematics teachers was also administered in Ireland. All test and questionnaire data (with the exception of the national teacher questionnaire) are weighted to ensure that they are nationally representative.

More detail on all aspects of the administration of PISA 2022 is available in *Education in a Dynamic World: the performance of students in Ireland in PISA 2022* (Donohue et al, 2023b) and the *PISA 2022 Technical Report* (OECD, 2024).

1.2. Policy context

Ireland's participation in PISA affords both the opportunity to observe developments and trends in the performance of students in Ireland, and to benchmark this performance against their peers internationally. Furthermore, the achievement data when analysed in conjunction with the contextual data provided by the background questionnaires offer the potential to inform future education policy.

Indeed, PISA has informed policy in Ireland for a number of years, including in the *Action Plan for Education 2016-2019* (Department of Education and Skills [DES],

2016), which set out three PISA targets to be attained by 2025. These targets related to increasing the proportion of students performing at the highest levels of proficiency, a reduction in the proportion of students performing at the lowest levels of proficiency in mathematics and science, and improving Ireland's international ranking in mathematics. Similar targets were included in the *National Strategy for Literacy and Numeracy* (DES, 2011; 2017a).

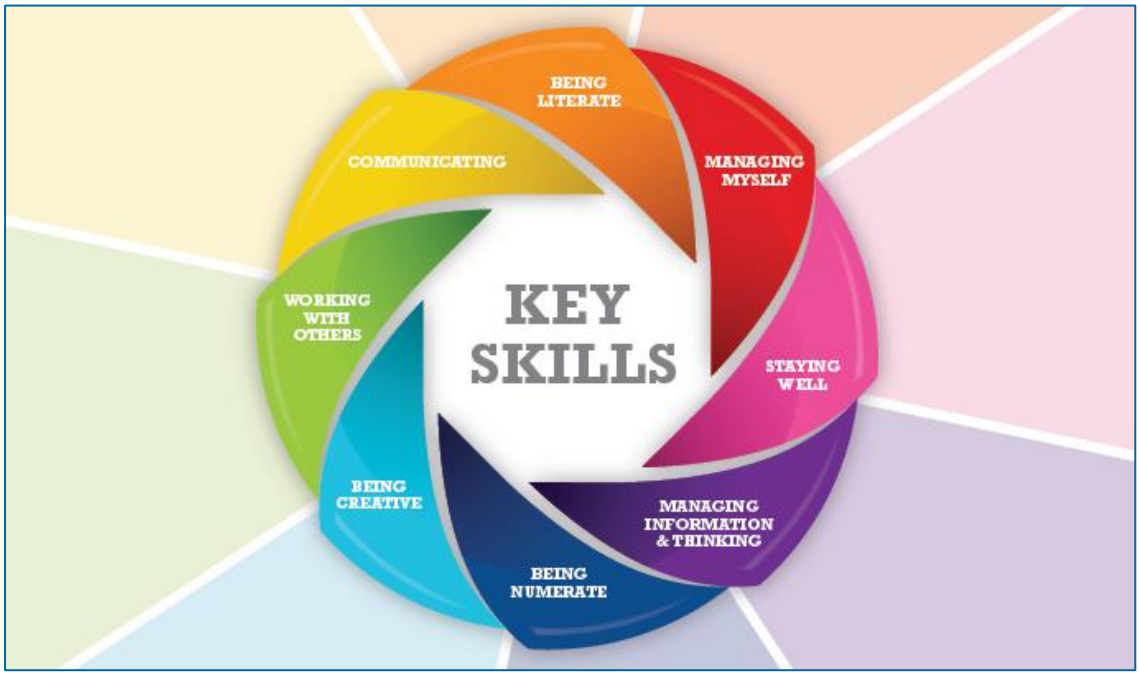
PISA is also cited as providing achievement benchmarks, along with the Trends in International Mathematics and Science Study (TIMSS), for evaluating post-primary Science, Technology, Engineering, and Mathematics (STEM) education in the *STEM Education Policy Statements 2017-2026* (DES, 2017b), and the *STEM Education Implementation Plan 2017-2019* (DES, 2017c). These seek to address some challenges in STEM education, including efforts to significantly improve problem-solving and inquiry-based learning for students in Ireland. The core pillars of this policy include fostering engagement and participation, and using evidence to support STEM education.

1.2.1. Junior Cycle framework

The Junior Cycle is comprised of Grade 7 to Grade 9 (called First Year to Third Year in Ireland). The framework that currently governs the Junior Cycle was published in 2015 (DES, 2015), with the intention of delivering balance between the acquisition of knowledge and skills, and the provision of a broader range of assessment types.

The framework is built around eight principles, twenty-four outcome-related statements of learning, and eight key skills. These skills (Figure 1.1) are deemed to be essential to learning in the context of the curriculum, and in the outside world. The subject specifications set out learning outcomes aimed at strengthening students' proficiency in these skills in the context of the subject.

Figure 1.1 - The key skills of the Junior Cycle



Source: Adapted from DES, 2015

The mathematics specification considers mathematics as an "interconnected body of ideas and reasoning processes" and aims not just to develop capabilities within the subject itself, but also to help students understand how aspects of mathematics such as understanding error, interpreting data and understanding timelines relate to subjects beyond mathematics (NCCA, 2018, p. 4). Proficiency in mathematics is deemed to have five connected components: understanding concepts, fluency in procedures, strategic competence, adaptive reasoning and productive disposition.

The subject specification for mathematics has four contextual strands (number; geometry and trigonometry; algebra and functions; and statistics and probability), and a unifying strand, that covers elements such as building blocks, representation, connections, problem-solving, generalisation and proof, and communication.

This updated subject specification for mathematics was launched in September 2018. The vast majority of students who participated in PISA 2022 in Ireland have been taught mathematics under the new subject specification, with the exception of the small group of Sixth Year students who made up 0.5% (weighted) of the sample (Table 1.2). However, it is important to note that schooling was interrupted from March 2020 due to Covid-19, just over 18 months after the new specification was launched.

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2. Mathematics performance in Ireland

As noted in Chapter 1, mathematics was the major domain of PISA 2022; therefore, as well as describing overall achievement in mathematics, the results also describe students' performance across different mathematical content areas and cognitive processes. Students' achievement in these content areas and cognitive processes can be compared to the corresponding results from PISA 2012, the last cycle in which mathematics was assessed as the major domain.

This chapter presents a summary of the mathematics results for Ireland, which were published in December 2023 in the national report for Ireland, *Education in a Dynamic World: the performance of students in Ireland in PISA 2022* (Donohue et al, 2023b), and can be found at www.erc.ie/pisa/publications. Also presented in this chapter are the results for students in Ireland across the mathematical content areas and cognitive processes.

2.1. Overall mathematics performance in Ireland

In PISA 2022, students in Ireland achieved a mean score of 491.6 in mathematics, which is significantly above the corresponding OECD average score (472.4). Nine countries[2] achieved significantly higher mean scores than Ireland in mathematics, while eight countries, including the United Kingdom, Australia and six EU countries, had similar mathematics performance to Ireland's. Male students significantly outperformed female students in mathematics, both in Ireland and on average across OECD countries, although the gender difference was larger in Ireland (13 points) than at the OECD average (9 points).

As well as describing average performance within a country or economy, PISA also describes performance in terms of proficiency levels[3] which outline the types of tasks that students can be expected to complete at each level. Six levels of proficiency are described for mathematics, with Level 6 representing the highest level of proficiency. Level 2 is described as the baseline level of proficiency needed to fully participate in society and students performing below this level can only correctly answer the very

[2] Canada, Chinese Taipei, Estonia, Hong Kong (China), Japan, Korea, Macao (China), Singapore and Switzerland significantly outperformed Ireland in mathematics.
[3] More information on PISA proficiency levels, including descriptions of the types of tasks that students at each level can be considered able to complete, is available in the OECD's (2023a) *PISA 2022 Results (Volume I)* at www.oecd.org/pisa.

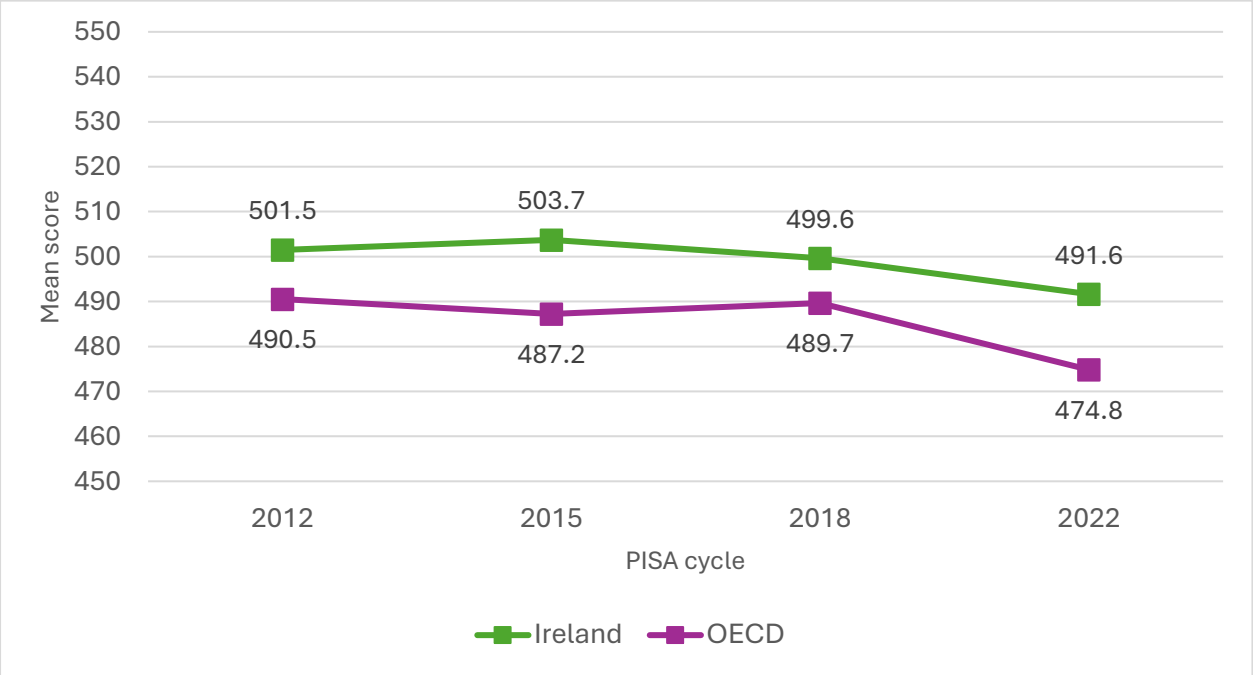
easiest questions in the PISA test. Level 1 is subdivided into three levels (Levels 1a, 1b and 1c) which describe in detail the types of tasks students performing below baseline proficiency are able to complete.

In PISA 2022, 19.0% of students in Ireland performed below baseline proficiency in mathematics, compared to an OECD average of 31.1%. On the other hand, 7.2% of students in Ireland reached the highest levels of proficiency (i.e., Levels 5 and 6), slightly lower than the OECD average of 8.7%.

2.1.1. Trends in mathematics performance from 2012 to 2022

Overall mean mathematics performance in Ireland, and on average across OECD countries, remained relatively stable between 2012 and 2018. Between 2018 and 2022, however, there were significant declines in the mean mathematics performance of students in Ireland and on average across OECD countries. The decline in mean performance was less pronounced in Ireland (-8 points) than at the OECD average (-15 points). In each cycle of PISA between 2012 and 2022, Ireland's mean mathematics score was significantly above the corresponding OECD average score.

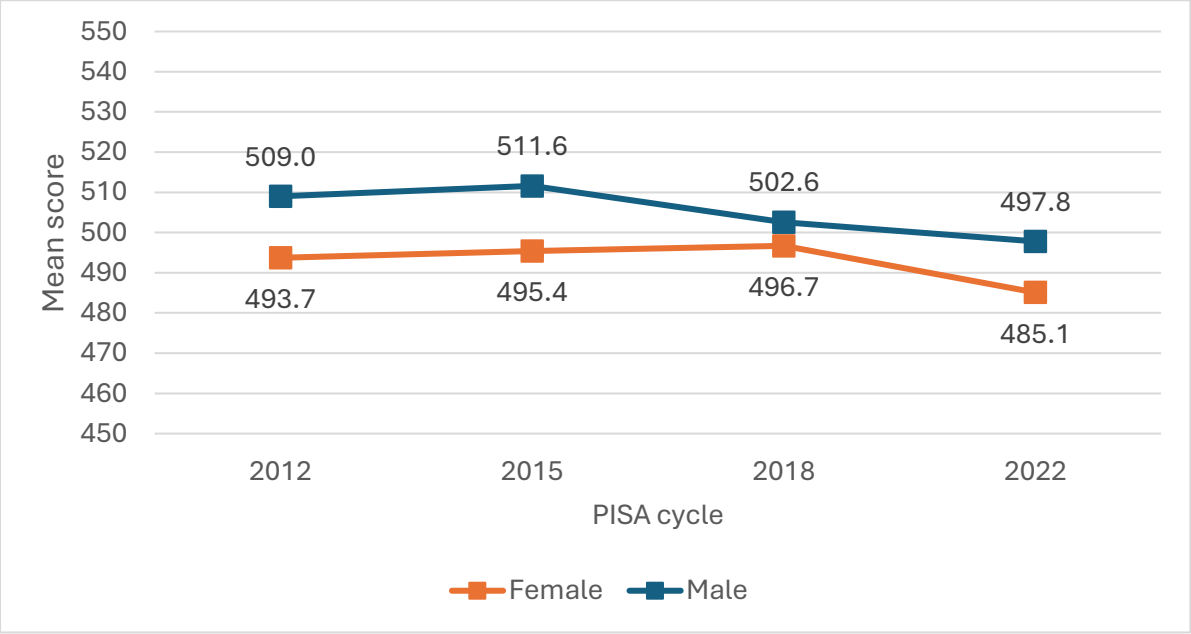
Figure 2.1 - Mean mathematics scores between 2012 and 2022, in Ireland and at the OECD average



Source: e-appendix Figure A2.1.

Since 2012, male students in Ireland have, on average, achieved higher mathematics scores than female students, although this difference was smaller and not statistically significant in 2018 (Figure 2.2). While the mean mathematics performance of both male and female students remained relatively stable between 2012 and 2015, a significant decline in the mean performance of male students in 2018 narrowed the gender gap to a non-significant difference of six points. In 2022, a non-significant drop of five points for male students and a significant drop of 12 points for female students resulted in a widening of the gender gap to 13 points in favour of male students.

Figure 2.2 - Mean mathematics scores of male and female students between 2012 and 2022, in Ireland



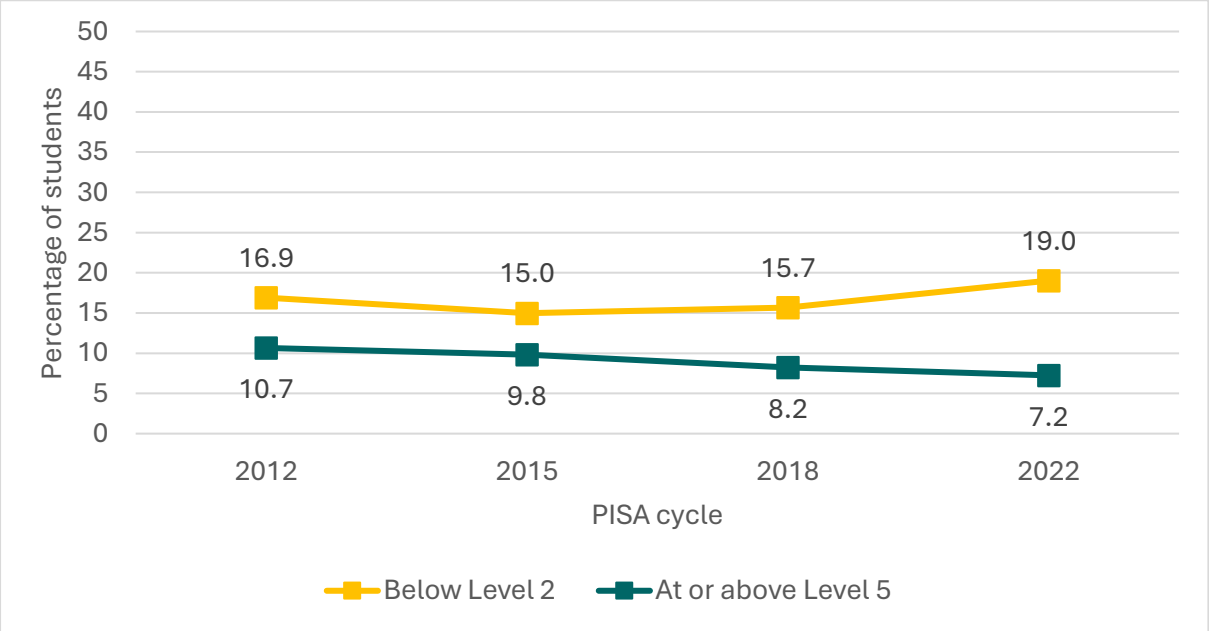
Source: e-appendix Figure A2.2.

In Ireland, the percentage of students performing below baseline proficiency in mathematics (i.e., below Proficiency Level 2) decreased by two percentage points between 2012 and 2015 and remained relatively stable between 2015 and 2018 (Figure 2.3). This indicates a small improvement in the mathematics performance of lower-achieving students in Ireland occurred during this period. However, in 2022,

the percentage of students performing below baseline proficiency increased significantly to 19.0%.

The improvement among lower-achieving students in mathematics between 2012 and 2018 in Ireland was most notable among female students. The percentage of female students performing below baseline proficiency in mathematics decreased from 18.7% to 15.7% during this period, while the corresponding percentage for male students increased very slightly, from 15.2% to almost 15.7%. On the other hand, the significant increase in students performing below baseline proficiency in 2022 was slightly larger for female students (+3.9 percentage points) than for males (+2.9 percentage points), with 19.6% of females performing below Level 2 compared to 18.5% of male students in 2022.

Figure 2.3 - Percentage of students performing below Proficiency Level 2 and at or above Proficiency Level 5 on overall mathematics between 2012 and 2022, in Ireland



Source: e-appendix Figure A2.3.

At the other end of the performance distribution, the percentage of students performing at the highest levels in PISA mathematics (i.e., Levels 5 and 6) in Ireland decreased steadily from almost 11% in 2012 to just over 7% in 2022 (Figure 2.3). Between 2012 and 2018, the decrease in the percentage of higher-performing students was greater among male than female students. During this time the

percentage of male students performing at Level 5 or above decreased from 12.7% to 9.9%, while the corresponding percentage of female students decreased from 8.5% to 6.6%. On the other hand, the one percentage point decrease in higher-achieving students between 2018 and 2022 was driven by a decrease among higher-achieving female students. The percentage of higher-achieving female students decreased by almost two percentage points to 4.7% in 2022, while the corresponding percentage of male students remained relatively stable at 9.6%.

PISA also describes students' performance across different mathematical content areas and cognitive processes, which will be outlined in more detail in the sections that follow.

2.2. Performance across mathematical content areas

There were four mathematical content areas assessed in PISA 2022 (OECD, 2023b):

- **Change and relationships** refers to using suitable mathematical models to describe and predict change, through understanding types of change and knowing when they occur. In mathematical terms, this means modelling the change and the relationships with appropriate functions and equations, as well as creating, interpreting, and translating among symbolic and graphical representations of relationships. Growth phenomena is a focal point of this content area, in particular recognising that not all growth is linear, that non-linear growth has implications for how certain situations are understood, and that 'exponential growth' means an extremely rapid rate of growth.
- **Space and shape** includes patterns, properties of objects, positions and orientations, representations of objects, decoding and encoding of visual information, navigation and dynamic interaction with real shapes as well as with representations, movement, displacement, and the ability to anticipate actions in space. Geometry is central to this content area, but elements of other areas such as spatial visualisation, measurement, and algebra are also relevant to space and shape. Geometric approximation is given special emphasis in PISA space and shape.

- **Quantity** incorporates the quantification of attributes of objects, relationships, situations, and entities in the world; understanding various representations of those quantifications; and judging interpretations and arguments based on quantity. Engaging with the quantification of the world requires an understanding of measurements, counts, magnitudes, units, indicators, relative size and numerical trends and patterns. As PISA mathematics is assessed using a computer-based format in 2022, students can engage in a broad category of complex problems using computer simulations, which is a focal point of the quantity content area in PISA mathematics.
- **Uncertainty and data** includes understanding the place of variation, and its quantification, in processes, as well as knowing about chance and about uncertainty and error in measurement. Conditional decision-making is a focal point of the uncertainty and data content category in PISA.

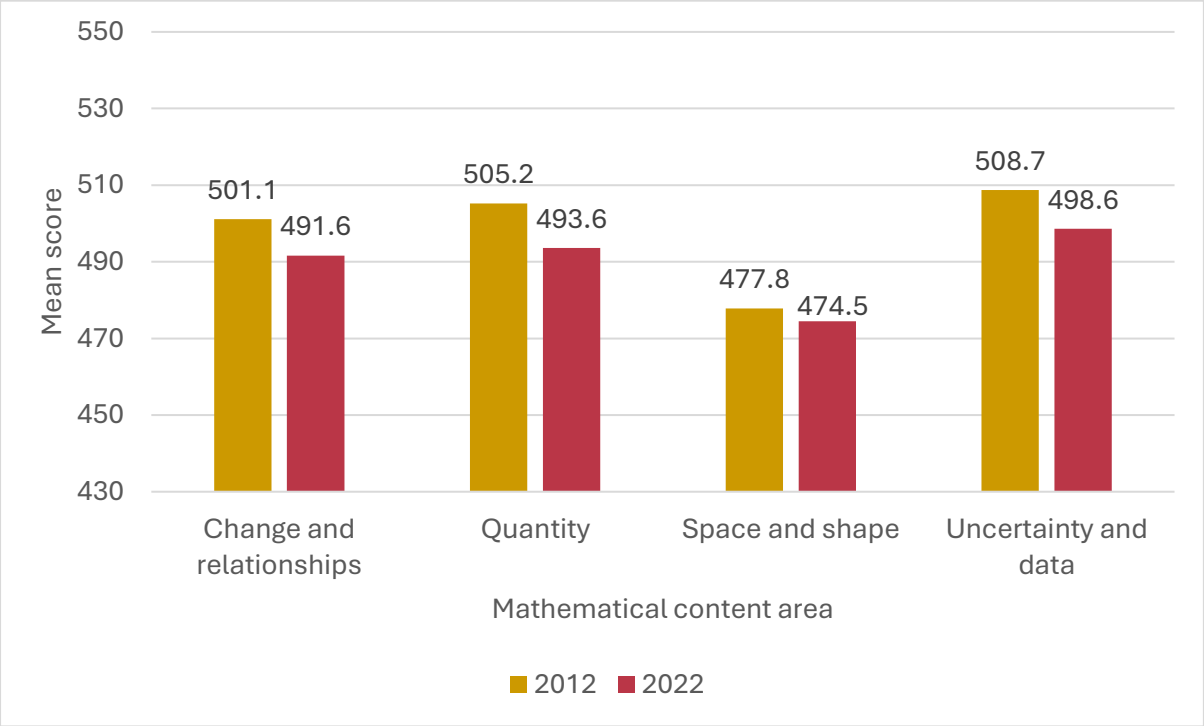
These four content areas are considered to reflect the mathematical phenomena that underlie broad classes of problems as well as broadly aligning with the major strands of typical school curricula (OECD, 2023b). Items in the PISA mathematics test are assigned to one of the four categories based on the main content knowledge that is considered to be associated with the item, but it should be noted that some test items could potentially be classified in more than one content category.

The four content areas outlined in PISA 2022 are the same as those described in PISA 2012, the last cycle where mathematics was assessed as the major domain. This means that student performance in the four content areas can be compared across the two cycles. When linking performance data across PISA cycles, error related to changes in the assessment design needs to be accounted for. This error may be related to changes in the assessment frameworks, mode of delivery, scaling methods and changes from major to minor domain (OECD, 2024). In PISA 2022, link error estimates are provided for each of the assessment domains (i.e., reading, mathematics and science) but not for the subdomains (i.e., the mathematical content and process areas). Therefore, while broad comparisons can be made on the mathematical content and process areas between 2012 and 2022, it is not possible to establish if differences in performance on these subscales between the two cycles are statistically significant. Also, as mathematics was assessed as a minor domain in

2015 and 2018, student performance is not described for the mathematical content or process areas for these cycles.

Figure 2.4 presents the mean scores for students in Ireland on each of the four mathematical content areas in both 2012 and 2022. In both cycles, students in Ireland performed best in the area of uncertainty and data, followed by quantity and then change and relationships. In both 2012 and 2022, students in Ireland performed considerably less well in the area of space and shape, when compared to the other content areas. Student performance dropped across all content areas between 2012 and 2022, although markedly less so in the area of space and shape (a slight drop of three points). The largest decline was in quantity (a drop of 12 points), followed closely by uncertainty and data (10 points) and change and relationships (nine points).

Figure 2.4 - Mean scores on the mathematical content areas in 2012 and 2022, in Ireland



Source: e-appendix Figure A2.4.

Male students in Ireland achieved significantly higher mean scores in each of the mathematical content areas compared to females, particularly in the area of space and shape where males outperformed female students by an average of 18 points

(Table 2.1). A similar pattern was observed on average across OECD countries, although the magnitude of the gender differences tended to be somewhat smaller, in particular in the areas of space and shape, and uncertainty and data.

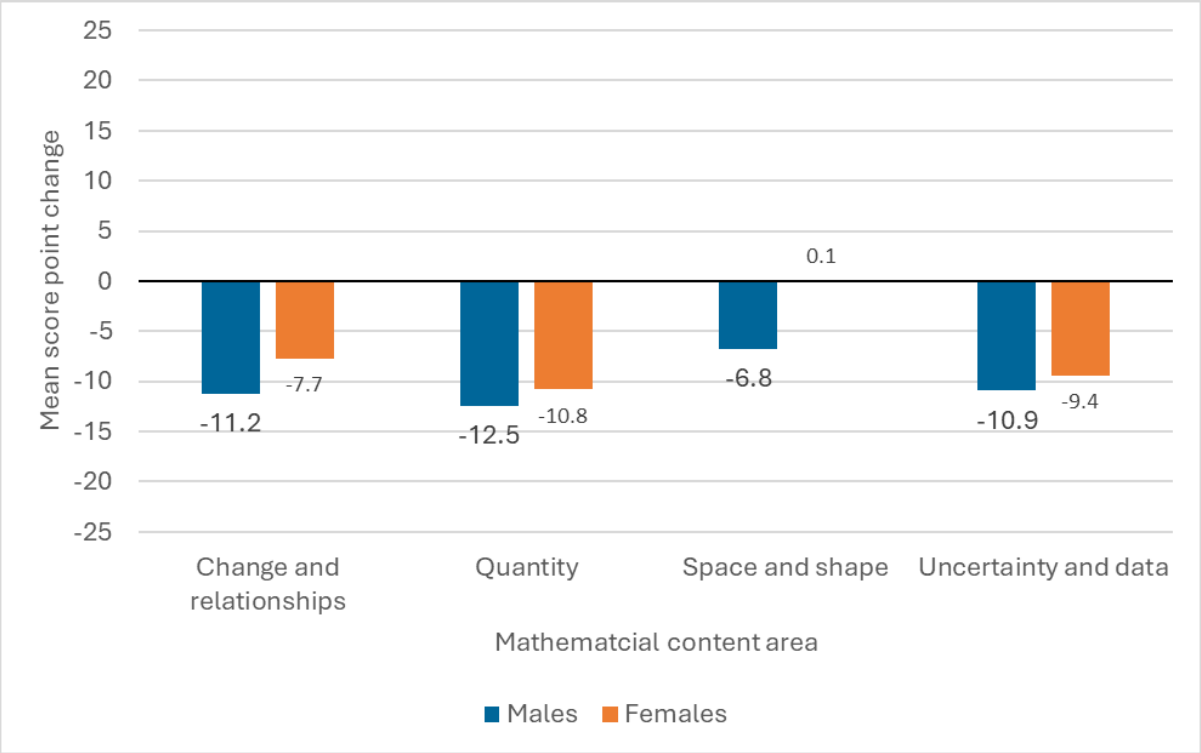
Table 2.1 - Mean scores of male and female students on each of the mathematical content areas in 2022, in Ireland and at the OECD average

		Male Mean	**Female** Mean	Difference (m – f)
Change and relationships	Ireland	496.5	486.6	**9.9**
	OECD	473.6	466.0	**7.6**
Quantity	Ireland	499.6	487.2	**12.4**
	OECD	478.0	466.8	**11.2**
Space and shape	Ireland	483.2	465.3	**17.9**
	OECD	476.6	464.4	**12.2**
Uncertainty and data	Ireland	504.8	492.1	**12.7**
	OECD	477.0	470.4	**6.6**

Source: e-appendix Table A2.1. Significant differences are highlighted in bold.

Across all content areas the decline in average performance since 2012 is larger for male than female students which has led to a narrowing of the gender differences across all content areas (Figure 2.5). The largest decline in average performance for male students was in the quantity content area (12.5 points) followed by change and relationships, and uncertainty and data (both about 11 points). A similar pattern was observed for female students, although the decline for females in uncertainty and data was slightly greater than in change and relationships. For space and shape, the average performance of female students remained stable between 2012 and 2022, while males' average performance in this area declined by almost seven points.

Figure 2.5 - Change in the mean scores of male and female students on each of the mathematical content areas between 2012 and 2022, in Ireland



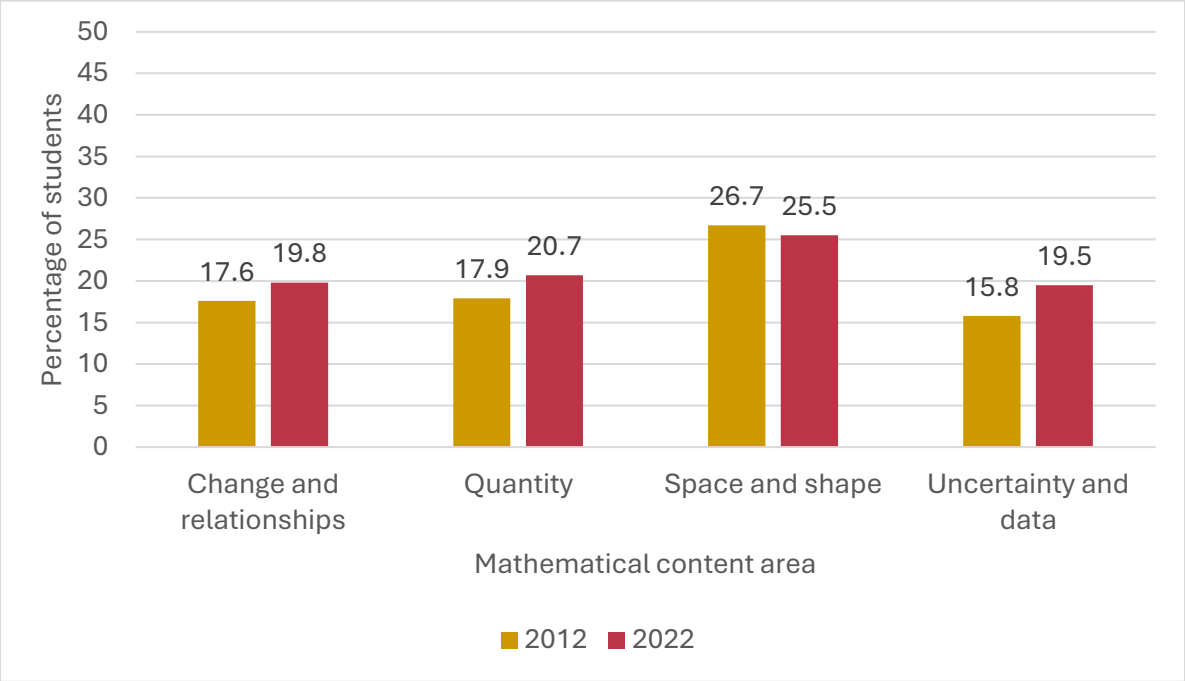
Source: e-appendix Table A2.2

Figure 2.6 presents the percentage of students in Ireland who performed below Level 2 (i.e., baseline level) on each of the four mathematical content area subscales in 2012 and 2022. On each subscale, except for the space and shape content area, the percentage of students performing below baseline level increased in Ireland between 2012 and 2022. These increases were greater among male than female students (see Table A2.3 in the e-appendix). This indicates that an increasing proportion of students, and particularly male students, are having difficulties answering some of the easiest questions on the PISA test across a range of content areas. The increase in lower-performing students was greatest in the uncertainty and data content area, which saw an increase of 3.7 percentage points, and while this increase was greater among male students (an increase of 4.4 percentage points), there was also an increase of three percentage points for female students (Table A2.3).

On the other hand, the percentage of students performing below baseline level on space and shape has declined slightly, from 26.7% in 2012 to 25.5% in 2022, primarily due to a decline in the percentage of lower-performing female students in

this area. In 2012, 30.7% of female students in Ireland performed below baseline level in space and shape, which dropped to 28.1% in 2022. On the other hand, the percentage of lower-performing male students in space and space in Ireland has remained stable at 23% in both cycles.

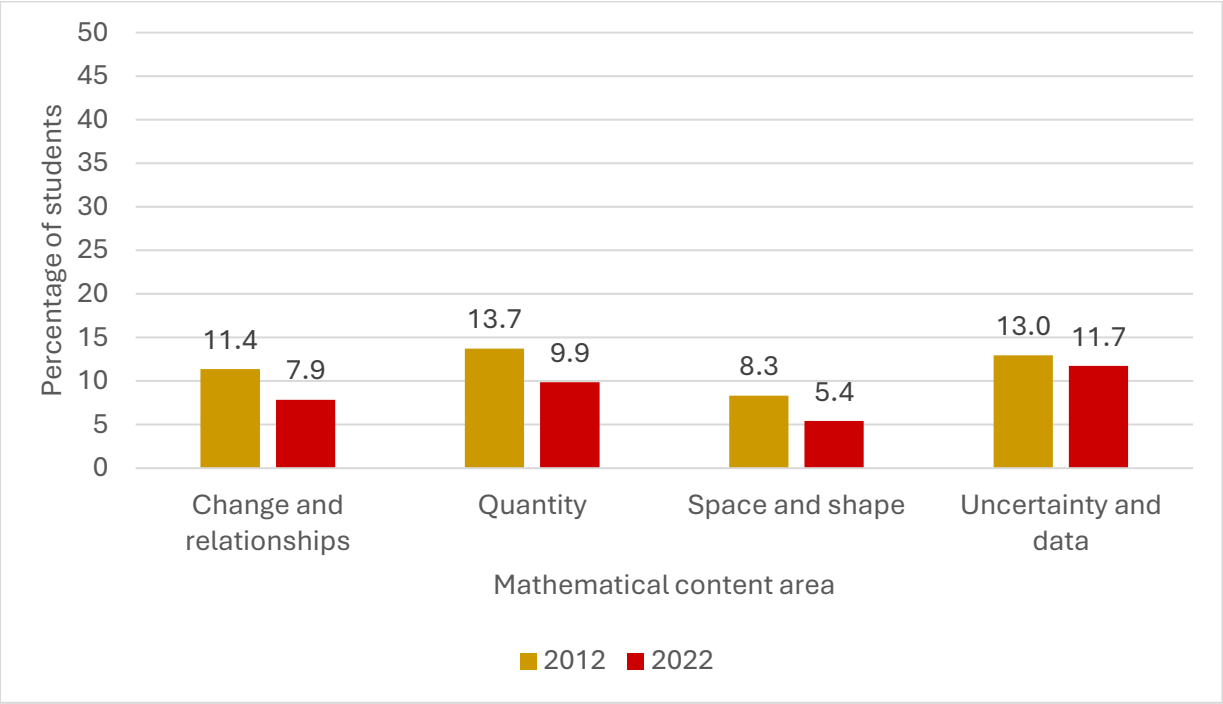
Figure 2.6 - Percentage of students performing below Proficiency Level 2 on each of the mathematical content areas in 2012 and 2022, in Ireland



Source: e-appendix Figure A2.5

At the other end of the performance distribution, the percentage of students in Ireland performing at the highest levels of the PISA test (i.e., Proficiency Levels 5 and 6) has declined in each of the mathematical content areas since 2012 (Figure 2.7). Uncertainty and data is the content area that saw the smallest drop in top-performing students (a decline of 1.2 percentage points), while the declines in the other content areas were in the region of three or four percentage points. With the exception of space and shape, the declines in the percentages of students achieving at the highest proficiency levels in the PISA mathematical content areas were slightly greater among female than male students in Ireland (see Table A2.4 in the e-appendix).

Figure 2.7 - Percentage of students performing at Proficiency Level 5 or above on each of the mathematical content areas between 2012 and 2022, in Ireland



Source: e-appendix Figure A2.6

2.3. Performance across mathematical cognitive processes

As well as examining student performance across different mathematical content areas, PISA also describes student performance in terms of mathematical cognitive processes which relate to mathematical reasoning and problem-solving processes. These four subscales measure aspects of the mathematical modelling cycle, where students make connections between the real world and the mathematical world and can use mathematical concepts, facts, procedures and reasoning to work on mathematically formulated problems:

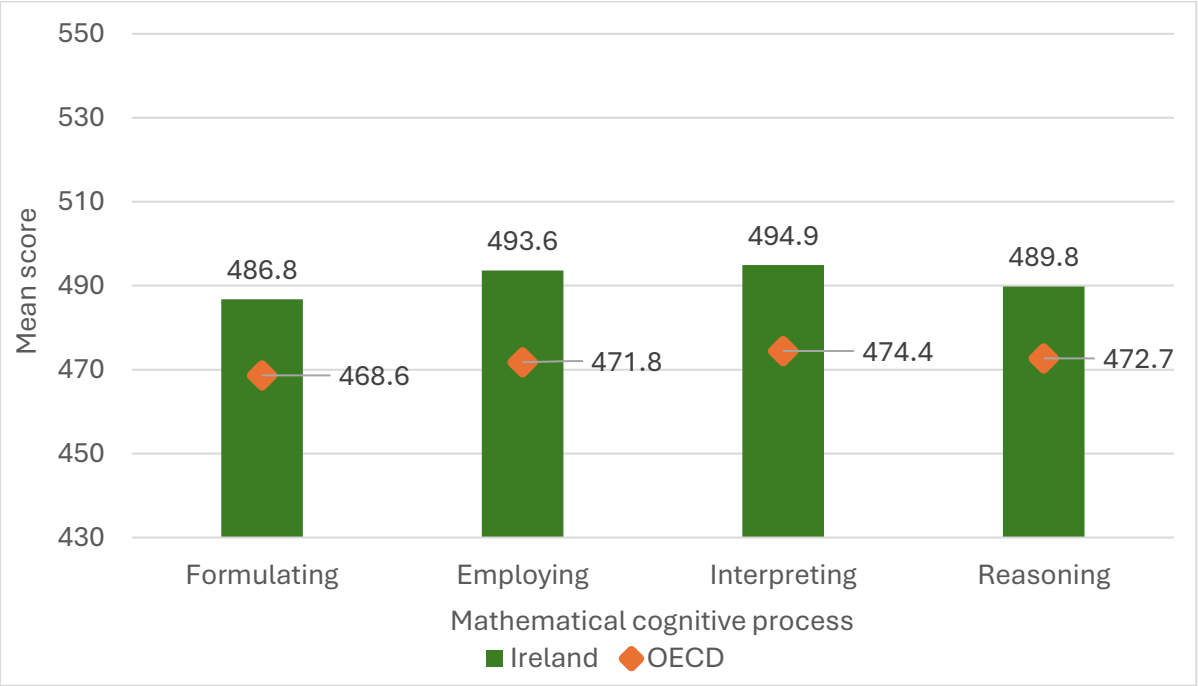
- **Formulating** involves transforming a real-world situation into a mathematical problem situation;
- **Employing** involves using mathematical concepts, facts and procedures to solve the mathematical problem;

- **Interpreting** involves reflecting on mathematical solutions and evaluating them in relation to the context of the problem, including determining whether the results make sense in the context of the problem situation;
- **Reasoning** involves evaluating situations, selecting strategies, drawing logical conclusions, developing and describing solutions, and recognising how those solutions can be applied (OECD, 2023b).

While the problem-solving model is made up of each of these processes, each PISA mathematics item was written specifically to measure one of these processes and students were not expected to use the full problem-solving model when answering each item. Reasoning has always been considered a core aspect of mathematical literacy in PISA; however, it was included as a separate subscale for the first time in 2022. Some trend items that had previously been classified according to the formulating, employing or interpreting processes, were reclassified as reasoning in 2022. For this reason, scores on the mathematical cognitive processes in 2022 are not compared to data from 2012 in this report.

Students in Ireland, on average, performed best on the interpreting subscale, followed closely by the employing subscale (Figure 2.8). Average performance in the area of reasoning was somewhat lower, and lowest on the formulating subscale. In each cognitive process area, students in Ireland performed, on average, considerably higher than their OECD peers.

Figure 2.8 - Mean scores on the mathematical cognitive processes in 2022, in Ireland and at the OECD average



Source: e-appendix Figure A2.7

On average, male students in Ireland significantly outperformed females in each of the cognitive process subscales (Table 2.2). The difference was largest for the formulating subscale where male students outperformed females, on average, by over 18 points. The gender difference was smallest on the interpreting subscale in Ireland, although male students still significantly outperformed female students by an average of eight points.

Table 2.2 - Mean scores of male and female students on each of the mathematical cognitive processes in 2022, in Ireland and at the OECD average

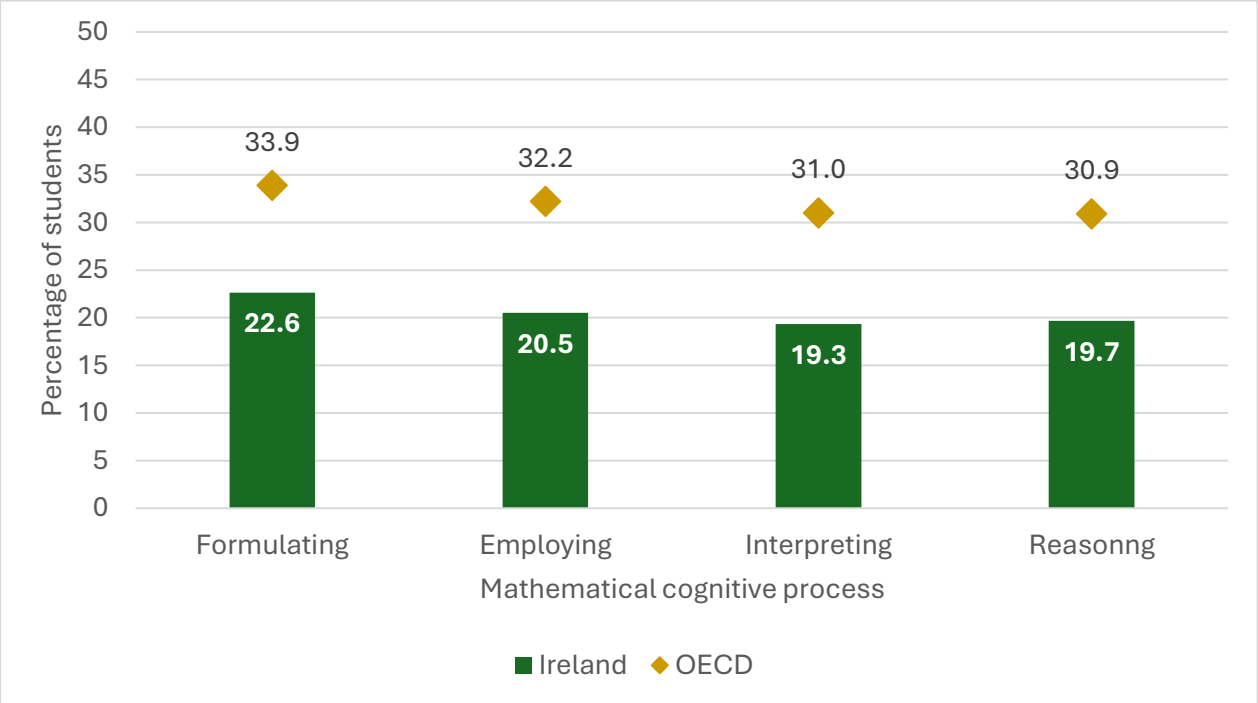
		Male Mean	**Female** Mean	Difference (m – f)
Formulating	Ireland	495.7	477.4	**18.3**
	OECD	475.8	461.3	**14.5**
Employing	Ireland	500.1	486.8	**13.3**
	OECD	476.7	466.8	**9.9**
Interpreting	Ireland	498.9	490.7	**8.2**
	OECD	477.0	471.8	**5.2**
Reasoning	Ireland	495.8	483.5	**12.3**
	OECD	477.2	468.1	**9.0**

Source: e-appendix Table A2.5. Significant differences are highlighted in bold.

Between 19% and 23% of students in Ireland performed below baseline proficiency across the four cognitive processes, compared to between 31% and 34% at the OECD average (Figure 2.9). Formulating was the subscale with the greatest proportion of students in Ireland performing below baseline proficiency (22.6%), followed by the employing subscale (20.5%). Just under 20% of students in Ireland performed below baseline proficiency on the interpreting and reasoning subscales.

Among lower-achieving students, the largest gender difference was observed on the formulating subscale. Just over 24% of female students in Ireland performed below baseline level on the formulating subscale compared to 21% of male students (see Table A2.7 in the e-appendix). The interpreting cognitive process is the area where the gender difference was narrowest among lower-achieving students in Ireland, with 19.0% of female students and 19.6% of male students performing below baseline level on this subscale.

Figure 2.9 - Percentage of students performing below Proficiency Level 2 on the mathematical cognitive processes in 2022, in Ireland and at the OECD average

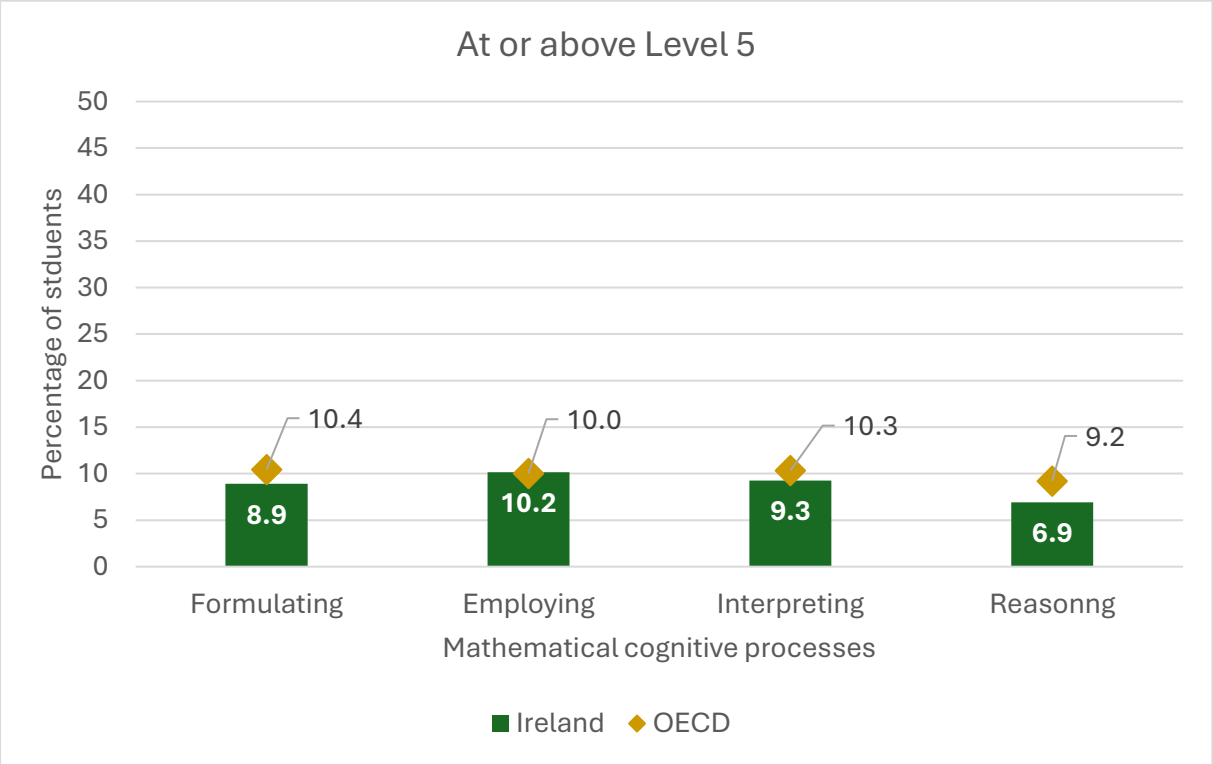


Source: e-appendix Table A2.6.

At the other end of the performance distribution, the percentages of students in Ireland who achieved scores at the highest proficiency levels (i.e., at or above Proficiency Level 5) ranged from 7% on the reasoning subscale to 10% on the employing subscale (Figure 2.10). The percentages of students reaching these levels in Ireland are similar to or slightly lower than at the corresponding OECD averages.

Gender differences across the four cognitive process subscales are larger among higher-achieving than lower-achieving students in Ireland (see Table A2.7 in the e-appendix). For each of the cognitive process subscales, a greater percentage of male than female students in Ireland performed at or above Level 5. The largest gender difference among higher-performing students in Ireland was observed on the formulating subscale, with almost 12% of male students and 6% of female students reaching this level.

Figure 2.10 - Percentage of students performing at Proficiency Level 5 or above on the mathematical cognitive processes in 2022, in Ireland and at the OECD average



Source: e-appendix Table A2.6

2.4. Summary

In PISA 2022, students in Ireland achieved an overall mean score that was significantly higher than the OECD average score. Nine countries achieved significantly higher mean scores than Ireland in mathematics, while eight countries had similar scores. Male students significantly outperformed female students in mathematics on average across OECD countries, and to a larger extent in Ireland.

PISA data outline performance at six levels of proficiency for mathematics, described in terms of a set of tasks that students at each level are able to perform. Level 6 is the highest level of proficiency, and Level 2 is described as the baseline level of proficiency needed to fully participate in society. In PISA 2022, a smaller percentage of students in Ireland performed below baseline proficiency, and also at the highest levels of proficiency, when compared to the OECD average.

Between 2018 and 2022 there were significant declines in the previously stable mean mathematics performance of students in Ireland and on average across OECD countries, with the decline less pronounced in Ireland. In each cycle of PISA between 2012 and 2022, Ireland's mean mathematics score was significantly above the OECD average score. Over this period, male students achieved higher mathematics scores than female students in Ireland, although in 2018 the gap was smaller and not statistically significant due to a significant decline in the performance of male students in 2018 compared to earlier cycles.

The percentage of students performing below baseline proficiency in mathematics (i.e., below Proficiency Level 2) dropped slightly from about 17% to 15% between 2012 and 2015 and remained stable in 2018 but increased significantly to 19% in 2022. The percentage performing at the highest levels in PISA mathematics (i.e., Levels 5 and 6) in Ireland decreased steadily from almost 11% in 2012 to just over 7% in 2022. The increase in the percentage of students in Ireland below baseline proficiency, and the decrease in the percentage at the highest levels between 2018 and 2022, is largely driven by a decrease in performance among female students.

PISA also describes mathematics performance in terms of four content areas: change and relationships, space and shape, quantity and uncertainty and data. In both 2012 and 2022, students in Ireland performed best in the area of uncertainty

and data, followed by quantity and then change and relationships. Students in Ireland performed considerably less well in the area of space and shape in both cycles. In line with overall performance, student performance dropped across all content areas between 2012 and 2022, but considerably less so in space and shape. Male students in Ireland performed significantly better in each of the mathematical content areas compared to females, and the gap was most pronounced in the area of space and shape, although the gender gap in this content area did narrow noticeably in 2022. This is due to the performance of male students in Ireland on this subscale declining since 2012, while the performance of female students was unchanged.

On three of the four mathematical content subscales, a higher percentage of students in Ireland performed below baseline proficiency in 2022 than in 2012, with the largest increase in the uncertainty and data subscale. These increases were greater among male students. On the other hand, there was a decline in the percentage of students performing below Level 2 in space and shape, largely due to a lower proportion of female students performing below baseline proficiency.

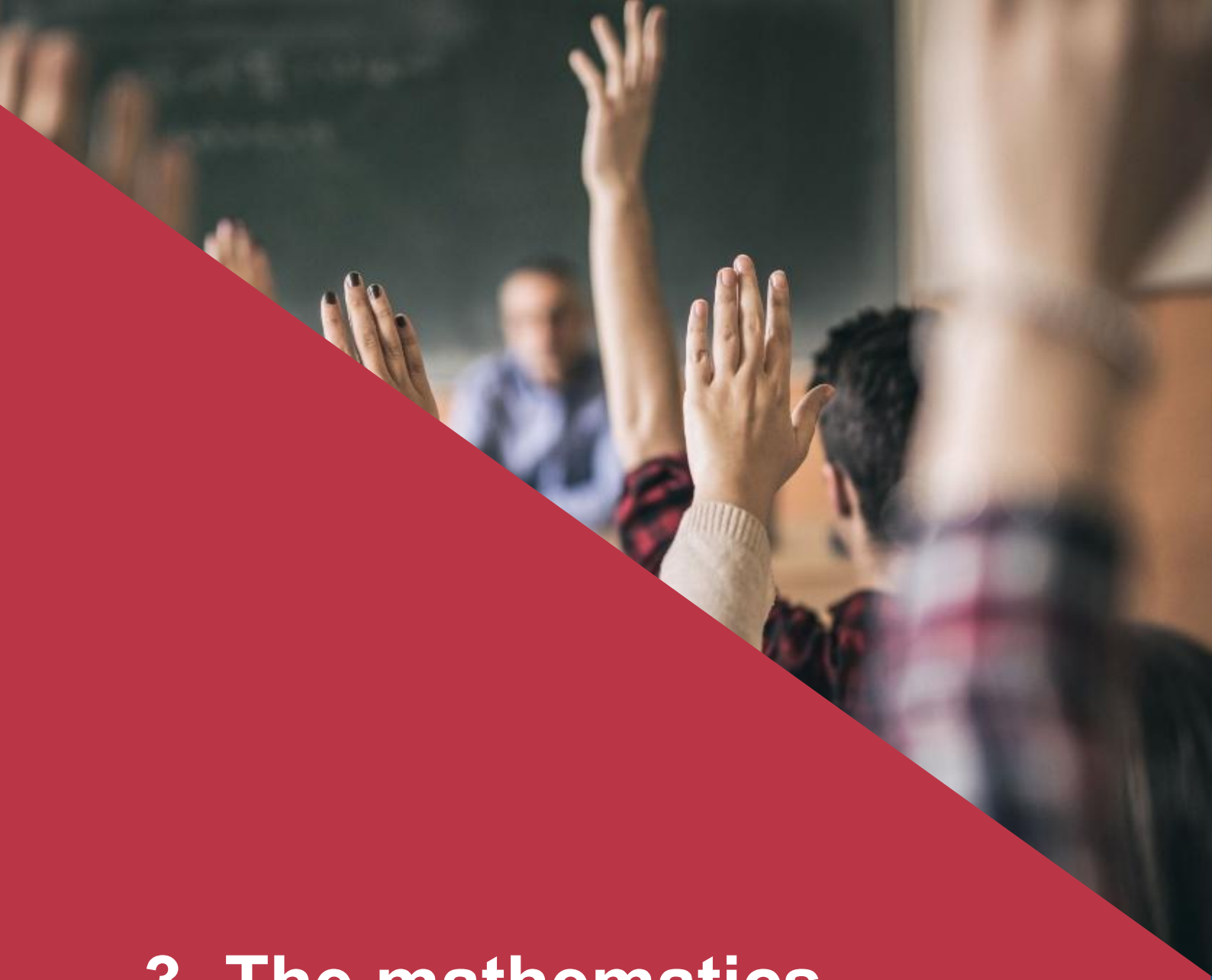
Across all four content areas there was a reduction in the proportion of students performing at the highest levels of proficiency (Levels 5 and 6) in 2022 when compared to 2012. There was a decline of just over one percentage point in the uncertainty and data content area, compared to a drop of three to four percentage points across the other content areas. The declines in percentage of students in Ireland performing at the highest levels were slightly greater among female than male students across all of the content areas except space and shape.

PISA also examines student performance in terms of mathematical cognitive processes which relate to mathematical reasoning and problem-solving processes. Students in Ireland, on average, performed best on the interpreting subscale, followed closely by the employing subscale. Average performance in the area of reasoning was somewhat lower, and lowest on the formulating subscale. In Ireland, male students outperformed females in each of the cognitive processes. The gap was greatest on the formulating subscale, and smallest on the interpreting subscale.

Across the four cognitive processes, between 19% and 23% of students in Ireland performed below the baseline proficiency levels, with the interpreting subscale

having the lowest proportion of students in Ireland performing below the baseline proficiency and formulating having the highest proportion. Female students in Ireland were more likely than males to perform below the baseline on the formulating subscale (24% compared to 21%). On the other hand, similar proportions of male (almost 20%) and female students (19%) in Ireland performed below baseline on the interpreting cognitive process.

Just over 10% of students in Ireland performed at the highest levels of proficiency on the employing subscale, with the proportions being slightly lower for the interpreting and formulating subscales. Almost 7% performed at the highest levels on the reasoning subscale. Gender differences across the four cognitive process subscales are larger among higher-achieving than lower-achieving students in Ireland and favour male students at the higher end of the performance distribution. The largest gender difference among higher-performing students in Ireland was on the formulating subscale, with almost 12% of male students and 6% of female students reaching this level.



3. The mathematics classroom

This chapter provides an analysis of aspects of the mathematics classroom as described by PISA. This includes the manner in which student learning of mathematics is organised at school, the disciplinary climate in mathematics classrooms, and also the use of digital devices in mathematics lessons. Data from Ireland are compared with the corresponding averages among students across OECD and European Union (EU) countries, and, in the case of composite indices, are also examined by gender.

3.1. Organisation of student learning in school

PISA measures the way student learning of mathematics is organised at school in terms of the student-mathematics teacher ratio and mathematics class size. The extent and manner of students being grouped by ability within and across mathematics classes is also described.

3.1.1. Student–mathematics teacher ratio

The student-mathematics teacher ratio is calculated by dividing the total number of students by the total number of full-time and part-time mathematics teachers, using data collected from schools. In Ireland, the mean student-mathematics teacher ratio was 78, meaning that on average there is one mathematics teacher for every 78 post-primary students in Ireland. This compares to a ratio of 83 on average across OECD countries, and 82 across EU countries (see Table A3.1 in the -appendix). The standard deviation for the student-mathematics teacher ratio in Ireland was 18.4, meaning that for 95% of post-primary students in Ireland, the student-mathematics teacher ratio in their school is between 41 and 115. The standard deviation for the student-mathematics teacher ratio across OECD countries was 19.3 and across EU countries was 18.2. These numbers do not indicate the size of base classes or mathematics classes (which is presented in the next section) but reflect the fact that subject teachers at second level teach the same subject to a number of different class groups.

3.1.2. Mathematics class size

The PISA school questionnaire asked principals to state the average mathematics class size in their school from a choice of nine categories ranging from “15 students or fewer” to “More than 50 students”, with the categories in between increasing in increments of 5. Average class size was calculated using the midpoint of each category and a value of 13 for the bottom category and 53 for the upper category. According to PISA data, the mean mathematics class size in Ireland was 24, which was on a par with the average across EU countries, and slightly lower than the OECD average of 25 (see Table A3.2 in the e-appendix). The standard deviation for this mean in Ireland was 3.3, meaning 95% of students in Ireland are in schools where the average mathematics class size is between 17 and 30 students. The standard deviation for the mean mathematics class size across OECD countries was 5.6 and across EU countries was 5.3, larger than the corresponding value for Ireland.

3.1.3. Mathematics class ability grouping

PISA also measured the ways in which schools group students by ability for mathematics classes, and the extent to which this occurs. This offers insight into the ways that schools vary mathematics content and levels of difficulty within and across groups. For each of the four types of ability grouping for mathematics classes (see Table 3.1), principals were asked whether these were used for all classes, for some classes or not for any classes.

Ability grouping between mathematics classes was more widespread in Ireland, compared to the average across OECD and EU countries. The majority of students in Ireland (57.7%) attended schools where mathematics classes study similar content, but at different levels of difficulty *for all classes*, while 38.0% were in schools where this form of ability grouping was used *in some classes* and 4.2% were in schools where this did not apply *for any class*. The percentages of students attending schools where this form of ability grouping applied *for all classes* was considerably lower at the OECD and EU averages (33.1% and 32.8%, respectively) than in Ireland (Table 3.1).

Different classes studying different content or sets of mathematics topics that have different levels of difficulty was also somewhat more prevalent in Ireland than on average across OECD and EU countries, with 69.9% of students in Ireland attending schools that grouped by ability that way *for some* or *all classes*, compared to 54.0% across OECD countries and 47.2% of students across EU countries.

Ability grouping *within* mathematics classes was also more prevalent in Ireland, with 36.5% of students in Ireland attending schools that group by ability in this way *for all classes*, compared to 12.7% of students across OECD countries and 9.7% of students across EU countries, on average. About 30% of students in Ireland are not grouped by ability in this way *for any classes*, compared to 54.2% of students across OECD countries and 58.6% of students across EU countries.

Conversely, students in Ireland are less likely to be in classes where teachers use pedagogy suitable for students of different abilities, i.e., students are not grouped by ability. In Ireland, 39.3% of students were in schools where this was the practice *for all classes*, which is considerably lower than the corresponding OECD (46.3%) and EU (51.6%) averages.

Table 3.1 - Percentages of students attending schools where the principal reported on the prevalence of types of ability grouping for mathematics classes, in Ireland and at the OECD and EU averages

		For all classes %	For some classes %	Not for any classes %
Mathematics classes study similar content, but at different levels of difficulty.	Ireland	57.7	38.0	4.2
	OECD	33.1	39.6	27.4
	EU	32.8	36.4	30.7
Different classes study different content or sets of mathematics topics that have different levels of difficulty.	Ireland	15.8	54.1	30.1
	OECD	16.3	37.8	46.0
	EU	13.7	33.6	52.8
Students are grouped by ability within their mathematics classes.	Ireland	36.5	33.6	29.9
	OECD	12.7	33.1	54.2
	EU	9.7	31.7	58.6
In mathematics classes, students are not grouped by ability.	Ireland	39.3	35.7	25.0
	OECD	46.3	34.3	19.4
	EU	51.6	32.0	16.4

Source: e-appendix Table A3.3

Based on principal-reported frequencies for the first two items in the above set of statements (Mathematics classes study similar content, but at different levels of difficulty and Different classes study different content or sets of mathematics topics that have different levels of difficulty), an index of ability grouping between mathematics classes was created, assigning schools to three different categories. Only 2.6% of students in Ireland attended schools where there was no ability grouping for any classes, compared to 22.9% of students across OECD countries and 26.8% of students across EU countries, on average. Similar proportions of students in Ireland (36.3%) and across OECD (38.7%) and EU (35.8%) countries, on average, attended schools where there was at least one form of ability grouping in some classes. A substantially higher proportion of students in Ireland (61.1%) attended schools where there was at least one form of ability grouping in all classes, compared to the averages across OECD (38.4%) and EU (37.5%) countries.

Table 3.2 - Percentages of students attending schools where the principal reported the extent of which students are grouped by ability for mathematics classes, in Ireland and at the OECD and EU averages

	No ability grouping for any classes	At least one form of ability grouping in some classes	At least one form of ability grouping in all classes
	%	%	%
Ireland	2.6	36.3	61.1
OECD	22.9	38.7	38.4
EU	26.8	35.8	37.5

Source: e-appendix Table A3.4

3.2. Disciplinary climate (students' reports)

Students were asked about the frequency with which a range of situations related to discipline occurred in their mathematics classes, with frequencies ranging from every lesson to never or almost never. These situations are related to negative or undesirable behaviours indicative of lower levels of discipline. Generally, there were slightly lower reports of these negative behaviours occurring in every lesson, along with higher reports of them occurring never or almost never, in Ireland than across the OECD and EU on average. The gap was most pronounced in relation to students getting distracted by technology such as smartphones and websites. In Ireland 19.8% of students reported that this occurred in most lessons or every lesson,

compared to 30.5% of students across OECD countries and 30.9% of students across EU countries, on average. Similarly, in Ireland 15.8% of students reported that students get distracted by other students using technology in most lessons or every lesson. This compares to a figure of just over 25% for students across OECD countries and EU countries, on average.

Table 3.3 - Percentages of students' reporting how often a range of situations occurred in their mathematics classes, in Ireland and at the OECD and EU averages

		Every lesson	Most lessons	Some lessons	Never or almost never
		%	%	%	%
Students do not listen to what the teacher said.	Ireland	8.5	20.3	51.8	19.4
	OECD	10.5	19.9	47.6	22.1
	EU	12.6	21.8	46.6	19.0
There is noise and disorder.	Ireland	8.6	20.5	43.3	27.6
	OECD	10.6	19.7	42.7	27.0
	EU	11.5	19.8	42.3	26.4
The teacher has to wait a long time for students to quiet down.	Ireland	5.8	14.1	41.8	38.3
	OECD	8.4	16.6	39.7	35.2
	EU	9.3	17.6	39.4	33.7
Students cannot work well.	Ireland	5.2	13.2	43.8	37.9
	OECD	7.1	15.5	42.8	34.6
	EU	7.8	16.5	42.3	33.4
Students do not start working for a long time after the lesson begins.	Ireland	6.0	14.9	38.7	40.3
	OECD	8.2	17.4	38.5	36.0
	EU	8.8	17.6	37.8	35.8
Students get distracted by using digital resources.	Ireland	6.3	13.5	29.4	50.8
	OECD	11.4	19.0	34.9	34.6
	EU	11.9	19.0	34.3	34.8
Students get distracted by other students who are using digital resources.	Ireland	5.4	10.4	30.0	54.2
	OECD	9.6	15.6	34.1	40.7
	EU	9.9	15.4	33.2	41.5

Source: e-appendix Table A3.5

The data shown in Table 3.3 were combined to create the index of disciplinary climate in mathematics. This index was scaled to have a mean of zero across OECD countries, and a standard deviation of one. A higher score on the index indicated a

better disciplinary climate in mathematics classes. Ireland had a mean score of 0.18, while the average score across OECD countries was 0.02 and across EU countries was -0.03. This indicates that, on average, students in Ireland perceive there to be a better disciplinary climate in their mathematics classes than their counterparts across the OECD and EU do.

Female students in Ireland reported a better disciplinary climate in their mathematics classes than male students did, and the difference was statistically significant. Similar patterns were observed across OECD and EU countries, on average, and these differences were also statistically significant.

Figure 3.1 - Mean scores on the index of disciplinary climate in mathematics, by gender, in Ireland and at the OECD and EU averages

Source: e-appendix Figure A3.1. Significant differences from the reference group are highlighted in bold.

3.3. Use of digital devices in mathematics lessons

3.3.1. School policy on the use of digital devices in mathematics instruction – principals' reports

School principals were asked whether their school has a policy on the use of digital devices in teaching mathematics. Examples given of things that might be governed by such a policy were the amount of computer use or the use of specific mathematics programmes in classes. In Ireland 31.4% of students attended schools where the principal reported that the school has a policy on how to use digital devices in mathematics instruction. This compares to 39.8% across OECD countries and 40.8% across EU countries, on average (see Table A3.6 in the e-appendix).

3.3.2. Use of digital devices in mathematics lessons – students' reports

Students were asked about the frequency with which they use digital resources in mathematics classes. In Ireland, 25.1% of students reported that they use digital resources in more than half of their mathematics classes, which was similar to the corresponding OECD and EU averages. A further 11.0% of students in Ireland reported that they used digital resources in about half of their mathematics classes, which was also similar to the OECD and EU averages, which were both 12.0%.

Table 3.4 - Percentages of students' reporting how often they used digital resources in their mathematics classes, in Ireland and at the OECD and EU averages

	Less than half of the lessons %	About half of the lessons %	More than half of the lessons %
Ireland	63.7	11.0	25.1
OECD	60.7	12.0	26.0
EU	62.0	12.0	24.6

Source: e-appendix Table A3.7. The percentages in the table do not add to 100% due to a small percentage of students who do not study mathematics

3.4. Summary

This chapter gave an overview of characteristics of the mathematics classroom measured by PISA data, namely the student-mathematics teacher ratio, class size, ability grouping, the disciplinary climate, and the use of digital devices in mathematics lessons.

The mean mathematics class size in Ireland was 24 students, which was the same as the EU average, and slightly lower than the OECD average of 25. When looking at the total number of mathematics teachers in a school, the student-mathematics teacher ratio in Ireland was 78 for post-primary students, reflecting the fact that subject teachers teach the same subject to a number of different class groups in post-primary schools. This compares to an average student-mathematics teacher ratio of 83 across OECD countries and 82 across EU countries.

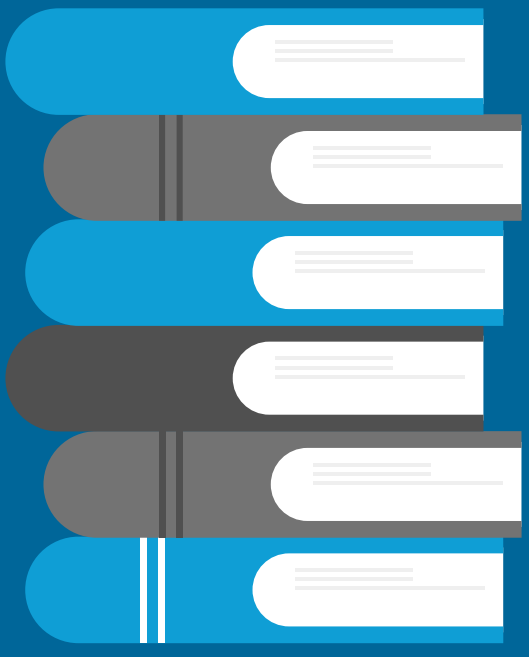
Almost all students in Ireland attended schools where there was some form of ability grouping for mathematics. Just 2.6% of students in Ireland were in a school where there was no ability grouping for mathematics, compared to 22.9% of students across the OECD and 26.8% of students across the EU on average. Conversely, substantially fewer students across OECD countries (38.4%) and EU countries (37.5%), on average, attended schools where there was at least one form of ability grouping in all classes. The corresponding figure for Ireland was 61.1%.

Students in Ireland had a noticeably more positive perception of the disciplinary climate in their mathematics classroom than their peers across OECD and EU countries did, on average. The gap was largest for distractions related to students using digital resources themselves or distractions caused by other students using digital resources in mathematics classes. Over half of students in Ireland reported that such distractions never occurred in mathematics lessons, which was substantially higher compared to their peers on average across OECD and EU countries. When broken down by gender, female students in Ireland, and across OECD and EU countries, on average, reported a better disciplinary climate in their mathematics classes; these differences were statistically significant.

Fewer students in Ireland (31.4%) attended a school where the principal reported that the school had a policy on the use of digital devices in mathematics classes

compared to the OECD average of 39.8% and the EU average of 40.8%. On the other hand, student reports on the frequency of using digital resources in mathematics classes were similar in Ireland and across OECD and EU countries, on average, with around a quarter of students reporting using digital devices in more than half of mathematics classes, and just over one-tenth using them in about half of lessons.

4. The teaching and learning of mathematics



This chapter provides an analysis of student experiences of the teaching and learning of mathematics in Ireland. The first section focuses on cognitive activation in mathematics lessons, in particular the extent to which students perceive that teachers foster reasoning and encourage mathematical thinking. The report then turns to creative pedagogies, looking at the extent to which students perceive that creativity is supported in mathematics classrooms in Ireland, and continues by examining teacher support, analysing how students perceive the availability of guidance and assistance from teachers. This support is assessed through students' reports of how often they feel actively supported and encouraged in their learning. Additionally, the report looks at students' learning strategies, with a focus on controlling their learning, as well as proactive mathematics study behaviours like effort and persistence. Each section compares findings from Ireland to averages across OECD and EU countries. The report also examines gender differences in students' reports of mathematics teaching and learning in Ireland and internationally.

4.1. Cognitive activation in mathematics lessons

In PISA, cognitive activation in mathematics lessons is measured using students' reports of a range of teacher behaviours. In particular, two dimensions of cognitive activation can be examined using the data available; that is, the perceived extent of teacher behaviours which foster mathematics reasoning and of teacher behaviours which encourage mathematical thinking.

4.1.1. Foster mathematics reasoning

Nine items in the questionnaire asked students to report how often their mathematics teacher showed a range of behaviours indicative of fostering mathematics reasoning (Table 4.1). This included asking students to justify their answers to a mathematics problem and asking students how they arrived at a solution when working on a mathematics problem.

Table 4.1 - Percentages of students reporting how often their mathematics teacher showed a range of behaviours indicative of fostering mathematics reasoning, in Ireland and at the OECD and EU averages

		Fewer than half of lessons	About half of the time	More than half of lessons
		%	%	%
The teacher asked us to solve mathematics problems without computing anything.	Ireland	60.1	21.7	18.2
	OECD	70.7	16.5	12.9
	EU	71.2	16.1	12.8
The teacher asked us to explain how we solved a mathematics problem.	Ireland	20.6	20.7	58.7
	OECD	27.5	24.3	48.2
	EU	27.2	24.4	48.3
The teacher asked us to explain what assumptions we were making when solving a mathematics problem.	Ireland	34.8	26.8	38.4
	OECD	35.6	26.8	37.6
	EU	35.1	26.8	38.1
The teacher asked us to explain our reasoning when solving a mathematics problem.	Ireland	20.9	22.1	57.0
	OECD	28.5	25.4	46.1
	EU	29.3	25.7	45.0
The teacher asked us to defend our answer to a mathematics problem.	Ireland	15.8	19.6	64.6
	OECD	31.8	24.5	43.7
	EU	31.2	24.6	44.1
The teacher asked us to think about how new and old mathematics topics were related.	Ireland	47.4	22.4	30.1
	OECD	43.8	25.0	31.2
	EU	44.2	25.1	30.7
The teacher encouraged us to think about how to solve mathematics problems in different ways than demonstrated in class.	Ireland	36.1	23.5	40.4
	OECD	38.7	24.6	36.7
	EU	40.1	24.9	35.0
The teacher told us to keep trying even when we face difficulties with a mathematics task.	Ireland	17.2	18.8	64.1
	OECD	25.2	22.9	51.9
	EU	27.2	22.8	50.0
The teacher taught us to memorise rules and apply them to solve mathematics problems.	Ireland	19.8	22.2	57.9
	OECD	24.2	23.6	52.2
	EU	24.2	23.5	52.3

Source: e-appendix Table A4.1

Across most items, students in Ireland reported a higher frequency of teaching behaviours indicative of fostering reasoning compared to the average of their EU and OECD peers. Notably, 64.6% of students in Ireland reported that their teachers asked them to defend their answers to a mathematics problem in more than half of the lessons, compared to 43.7% across OECD countries and 44.1% across EU countries, on average. Similarly, when it came to how often students reported being

asked to explain how they solved a mathematics problem, 58.7% of students in Ireland reported this occurring in more than half of the lessons which was higher than the OECD (48.2%) and EU (48.3%) averages. Also, 64.1% of students in Ireland indicated that their teachers told them to keep trying even when they faced difficulties with a mathematical task in more than half of the lessons, compared to 51.9% across OECD countries and 50.0% across EU countries, on average. On the other hand, the percentages of students in Ireland whose teacher frequently asked them how old and new mathematics topics were related (30.1%) was similar to the OECD and EU averages (31.2% and 30.7%, respectively).

The responses to these questions were combined to create an index of fostering mathematics reasoning, in order to reflect students' perceptions of how often their mathematics teacher showed a range of behaviours indicative of fostering mathematics reasoning. This index was standardised, with a mean of zero and a standard deviation of one across the 34 OECD countries that provided data. Ireland's average score on this index was 0.18, notably higher than the OECD average of 0.00 and the EU average of -0.01. This suggests that, on average, students in Ireland feel that their teachers exhibit behaviours that foster mathematics reasoning more frequently. Ireland's score on this index was only slightly lower than Portugal's (0.26), the OECD country with the highest mean score on this index across OECD and EU countries. Korea had the lowest score across OECD countries (-0.41).

In Ireland, there was a significant difference between the average male and female scores (Figure 4.1), indicating that male students, on average, perceive that their teachers display behaviours indicative of fostering mathematics reasoning more frequently than their female counterparts do. A much smaller, yet significant difference was found on average across the OECD countries. The average gender difference across EU countries was similarly small but not statistically significant.

Figure 4.1 - Mean scores on the index of fostering mathematics reasoning, by gender, in Ireland and at the OECD and EU averages

Source: e-appendix Figure A4.1. Significant differences from the reference group are highlighted in bold

4.1.2. Encourage mathematical thinking

As well as fostering reasoning, another aspect of cognitive activation in PISA is the degree to which mathematical thinking in students is encouraged by teachers during the school year. This construct is measured using student-reported frequencies of nine instructional practices (Table 4.2), such as how often teachers encourage students to "think mathematically" or how often teachers ask students how various topics are connected to a bigger mathematical idea.

In general, students in Ireland reported that most of the instructional practices listed occurred in at least half of lessons. The exceptions are teachers asking students to think of everyday problems that could be solved with new mathematics knowledge learned and showing students how mathematics can be useful in their everyday lives, with over 55% of students in Ireland indicating that these practices occurred in fewer than half of lessons. However, when compared against the OECD and EU averages, the differences were small. The practice that students in Ireland reported occurring most frequently was the teacher showing them how some problems that

look difficult can be solved more easily by understanding how the number system is organised, with 46.0% of students in Ireland indicating this happened in more than half of lessons. The corresponding OECD and EU average percentages were somewhat lower at 42.3% and 39.6%, respectively.

Table 4.2 - Percentages of students reporting how often their mathematics teacher showed a range of behaviours indicative of encouraging mathematical thinking, in Ireland and at the OECD and EU averages

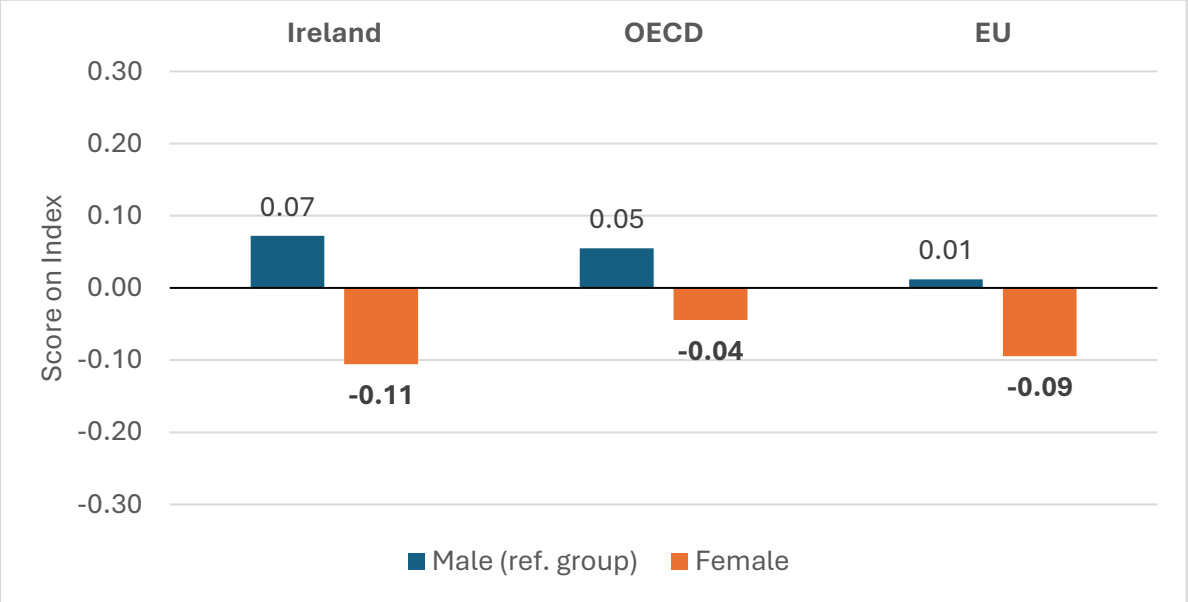
The teacher…		Fewer than half of lessons	About half of the time	More than half of lessons
		%	%	%
…asked us to think of problems from everyday life that could be solved with new mathematics knowledge we learned.	Ireland	56.7	22.2	21.2
	OECD	56.5	22.5	21.0
	EU	58.8	21.8	19.4
…showed us how mathematics can be useful in our everyday lives.	Ireland	55.4	21.8	22.8
	OECD	51.8	22.9	25.3
	EU	53.9	22.8	23.3
… encouraged us to "think mathematically".	Ireland	36.3	25.0	38.6
	OECD	37.3	25.5	37.2
	EU	37.4	25.9	36.6
… taught us how to use mathematical logic when approaching new situations.	Ireland	38.7	26.5	34.8
	OECD	39.8	26.6	33.6
	EU	42.1	26.9	31.0
… showed us how some problems that look difficult can be solved more easily by understanding how the number system is organised.	Ireland	27.4	26.7	46.0
	OECD	30.4	27.3	42.3
	EU	32.8	27.7	39.6
… gave problems from everyday life involving numbers and asked us to make a decision about the situation.	Ireland	48.1	24.9	27.1
	OECD	47.9	25.6	26.5
	EU	49.9	25.4	24.6
… asked us how different topics are connected to a bigger mathematical idea.	Ireland	44.0	27.2	28.9
	OECD	44.5	26.9	28.6
	EU	45.9	27.2	27.0
… encouraged us to think about how a problem from everyday life could be solved using mathematics.	Ireland	49.3	24.6	26.0
	OECD	48.1	24.2	27.6
	EU	49.7	24.2	26.1
… explained how different mathematical ideas connect to a larger context.	Ireland	42.1	27.1	30.8
	OECD	40.9	27.0	32.2
	EU	42.2	27.3	30.6

Source: e-appendix Table A4.2

These items were combined to make an index of encouraging mathematical thinking. Ireland's mean score on this index was -0.02, similar to the OECD's average score of 0.01 and the EU average of -0.04. This indicates that students in Ireland report similar levels of mathematical thinking being encouraged in the classroom by their teachers as their OECD and EU peers. Portugal was the EU country with the highest score on this index (0.29), while Columbia achieved the highest score across OECD countries (0.57).

In Ireland, and on average across OECD and EU countries, males had a significantly higher mean score than their female counterparts on the encouraging mathematical thinking index, suggesting they are more likely to perceive that their teachers encourage mathematical thinking in the classroom during the school year. However, the gender gap was more pronounced in Ireland than at the OECD or EU averages (Figure 4.2).

Figure 4.2 - Mean scores on the index of encouraging mathematical thinking, by gender, in Ireland and at the OECD and EU averages



Source: e-appendix Figure A4.2. Significant differences from the reference group are highlighted in bold

4.2. Creative pedagogies

This section presents an analysis of students' experiences with creativity within their school and classroom settings. It specifically examines students' views on how creativity is encouraged and nurtured in their schools. This index and other aspects of

creative thinking in schools in Ireland are explored in more detail in the *Cultivating Creativity* report (Donohue et al., 2024a).

Students in Ireland tended to strongly agree/agree, more than the average of their OECD and EU counterparts, with statements about creative thinking being fostered and supported in their school and class environment (Table 4.3).

Table 4.3 - Percentages of students reporting levels of agreement with various statements about the degree to which creative thinking is fostered and supported in their school and class environment, in Ireland and at the OECD and EU averages

		Strongly disagree/ Disagree %	Strongly agree/ Agree %
My teachers give me enough time to come up with creative solutions on assignments.	Ireland	30.2	69.8
	OECD	37.5	62.5
	EU	41.0	59.0
My teachers value students' creativity.	Ireland	24.9	75.1
	OECD	29.9	70.1
	EU	31.5	68.5
The activities we do in my classes help me think about new ways to solve problems.	Ireland	35.5	64.5
	OECD	37.5	62.5
	EU	40.4	59.6
My mathematics assignments require me to come up with different solutions for a problem.	Ireland	39.1	60.9
	OECD	37.5	62.5
	EU	40.2	59.8
My teachers encourage me to come up with original answers.	Ireland	24.9	75.1
	OECD	36.3	63.7
	EU	39.4	60.6
At school, I am given a chance to express my ideas.	Ireland	28.6	71.4
	OECD	30.7	69.3
	EU	33.0	67.0

Source: e-appendix Table A4.3

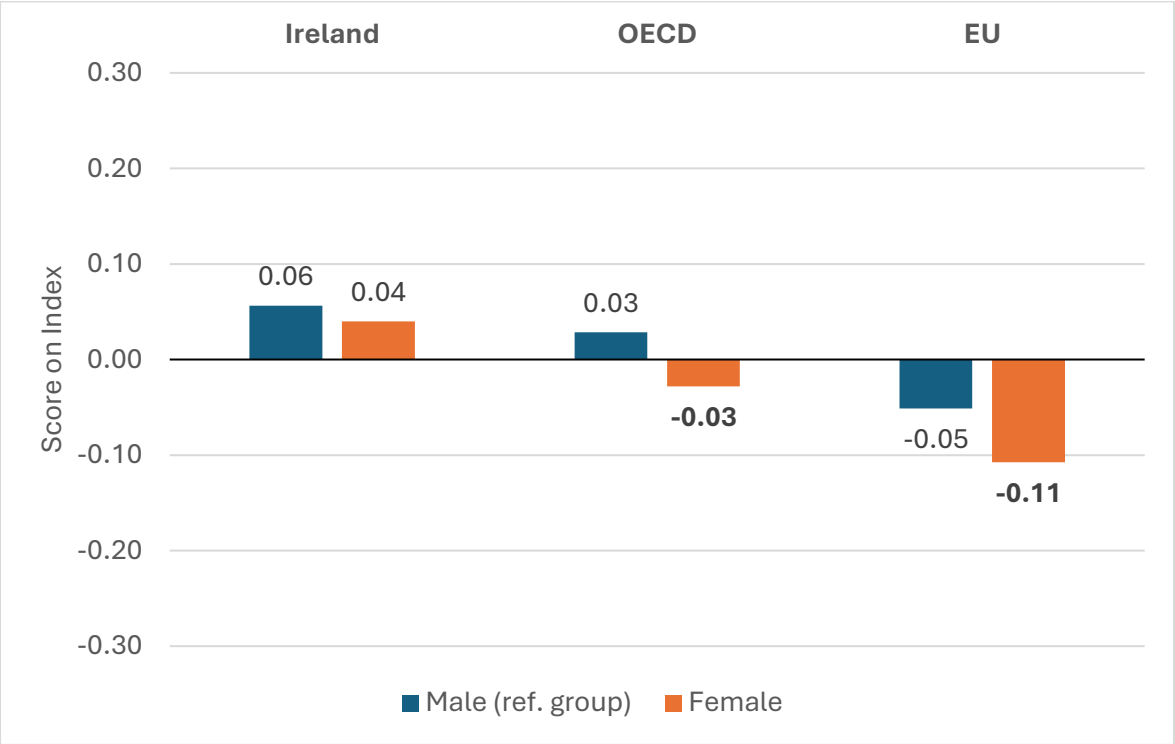
Students in Ireland were most likely to agree that their teachers encouraged them to develop original responses in class, and that their creativity was valued by teachers (both 75.1%). With regards to teachers encouraging students to come up with original responses, the percentage agreeing in Ireland was considerably higher than

at the OECD (63.7%) and EU (60.6%) averages. Students in Ireland were also much more likely to agree (69.8%) that their teachers give them enough time to come up with creative solutions on assignments than the average of their OECD (62.5%) and EU (59.0%) peers. On the other hand, the percentages of students agreeing that their mathematics assignments required finding different solutions to a problem was similar in Ireland (60.9%) and at the OECD (62.5%) and EU averages (59.8%).

To capture students' perceptions of creative teaching methods, an index of creative school and class environment was created by combining the data from students' responses to these questions. This index was standardised with a mean of zero and a standard deviation of one across OECD countries. Ireland's average score on this index was 0.05, above the OECD average of 0.00 and higher than the EU average of -0.08. This indicates that, on average, students in Ireland are slightly more likely to report that creative thinking is encouraged and supported in their schools compared to students across EU and OECD countries. Costa Rica had the highest mean score across OECD countries (0.48) while Portugal was the EU country with the highest score on this index (0.24).

In Ireland, male (0.06) and female (0.04) students had comparable average scores on the index of creative school and class environment (Figure 4.3), indicating no gender difference in the extent to which they feel creative thinking is fostered in their schools. In contrast, across the OECD and EU countries, male students were, on average, significantly more likely than female students to report that creative thinking is encouraged and supported in their school and classroom environments.

Figure 4.3 - Mean scores on the index of creative school and class environment, by gender, in Ireland and at the OECD and EU averages



Source: e-appendix Figure A4.3. Significant differences from the reference group are highlighted in bold

4.3. Mathematics teacher support

The following section examines how frequently certain supportive teacher behaviours are perceived to occur in classrooms, based on students' responses. In general, students in Ireland reported greater frequency of these behaviours than their OECD and EU peers did, on average, suggesting a higher perception of supportive teacher behaviours among students in Ireland (Table 4.4). In particular, students in Ireland were much more likely to agree that their teacher actively helped them with their learning (77.7%) than their OECD (71.6%) and EU (66.5%) peers, on average. In addition to this, 73.9% agreed that they received extra help from their teacher when needed in most or every lesson. This was higher than the averages for their OECD peers (70.2%), and EU peers (66.8%).

Table 4.4 - Percentages of students' reporting how often a range of situations occurred in their mathematics lessons, in Ireland and at the OECD and EU averages

		Most lessons/ Every lesson %	Some lessons / Never or Almost never %
The teacher shows an interest in every student's learning.	Ireland	65.5	34.5
	OECD	63.2	36.8
	EU	58.7	41.3
The teacher gives extra help when students need it.	Ireland	73.9	26.1
	OECD	70.2	29.8
	EU	66.8	33.2
The teacher helps students with their learning.	Ireland	77.7	22.3
	OECD	71.6	28.4
	EU	66.5	33.5
The teacher continues teaching until the students understand.	Ireland	63.8	36.2
	OECD	63.6	36.4
	EU	59.2	40.8

Source: e-appendix Table A4.4

An index of mathematics teacher support, measuring students' perceptions of supportive teaching methods, was created by combining the data from responses to these questions. Ireland's average score on this index was 0.07, which was higher than the OECD average of -0.03 and considerably higher than the EU average of -0.17. This indicates that, on average, students in Ireland feel more supported by their teachers than students, on average, across OECD and EU countries. Portugal was the highest performing country in the EU on this index with a mean score of 0.33, while Poland was the lowest (-0.69).

In Ireland, a notable difference was apparent between male and female students in terms of perceived teacher support in the classroom (Figure 4.4), with male students reporting higher levels of support from their teachers than female students, on average (a significant difference of 0.09 points). Similarly, a significant gender difference was also observed on average across OECD countries, with male students also reporting higher levels of perceived teacher support than female students, on average, albeit a smaller gap between the two genders of 0.05. At the EU average, the difference between the mean scores for males and females was wider than at the OECD average but was not statistically significant.

Figure 4.4 - Mean scores on the index of mathematics teacher support, by gender, in Ireland and at the OECD and EU averages

Source: e-appendix Figure A4.4. Significant differences from the reference group are highlighted in bold

4.4. Students' learning strategies

This section examines students' reports of their own learning strategies, focusing on two key aspects: self-regulation in learning and proactive mathematics study behaviours. The items that assessed students' ability to regulate their own learning examined their levels of agreement with statements related to impulse control, attention management, and careful decision-making, and captured traits such as checking work for mistakes, thinking carefully before acting or speaking, and maintaining focus on tasks. In terms of proactive mathematics study behaviours, students reported on various statements which evaluated how frequently they engage in behaviours indicative of effort and persistence in mathematics learning, such as participating in group discussions, asking questions, paying attention during lessons, and starting assignments promptly.

4.4.1. Controlling one’s own learning

This section examines students' perception of their control of their own learning (Table 4.5). Students in Ireland were generally less likely to agree with statements indicative of higher levels of self-regulation, and more likely to agree with statements associated with lower levels of self-regulation, than the average of their OECD and EU counterparts (Table 4.5). In particular, 67.1% of students in Ireland agreed that they get easily distracted, which was notably higher than the OECD average (54.1%) and the EU average (51.5%), while 56.2% of students in Ireland indicated they like to ensure there are no mistakes, which was considerably lower than the OECD (64.2%) and the EU (62.6%) averages. Furthermore, 36.3% of students in Ireland reported carefully reviewing their homework before turning it in, lower than the corresponding percentages at the OECD (44.3%) and the EU (39.2%) averages. However, 69.3% of students in Ireland agreed that they wait their turn to speak in class, a percentage higher than the OECD (64.3%) and the EU (62.6%) averages.

Table 4.5 - Percentages of students reporting levels of agreement with statements about control of their learning, in Ireland and at the OECD and EU averages

		Strongly disagree/ Disagree %	Neither agree or Disagree %	Strongly agree/ Agree %
I am careful with what I say to others.	Ireland	10.1	18.4	71.5
	OECD	12.6	19.5	67.9
	EU	13.1	20.1	66.9
I get easily distracted.	Ireland	13.6	19.3	67.1
	OECD	23.3	22.6	54.1
	EU	24.9	23.6	51.5
I say the first thing that comes to my mind.	Ireland	36.0	29.4	34.5
	OECD	41.1	27.9	31.0
	EU	41.8	28.2	30.1
I like to make sure there are no mistakes.	Ireland	14.8	29.0	56.2
	OECD	12.8	23.0	64.2
	EU	13.7	23.7	62.6
I carefully check homework before turning it in.	Ireland	36.7	27.0	36.3
	OECD	29.5	26.2	44.3
	EU	33.1	27.6	39.2
I stop to think before acting.	Ireland	21.2	29.8	49.0
	OECD	15.8	27.6	56.5
	EU	15.8	28.0	56.1
I rush into activities without thinking.	Ireland	36.1	28.8	35.1
	OECD	44.1	30.0	26.0
	EU	44.8	29.7	25.6
I wait for my turn to speak in class.	Ireland	10.4	20.3	69.3
	OECD	13.9	21.8	64.3
	EU	15.0	22.3	62.6
I am more impulsive than most people I know.	Ireland	29.9	37.5	32.6
	OECD	35.7	35.0	29.3
	EU	34.0	35.9	30.1
I think carefully before doing something.	Ireland	19.1	29.3	51.6
	OECD	16.1	29.5	54.4
	EU	16.7	30.1	53.1

Source: e-appendix Table A4.5

4.4.2. Proactive mathematics study behaviour

This section presents the findings from students' responses regarding the frequency with which they exhibited behaviours indicative of effort and persistence in mathematics.

Students in Ireland reported higher frequencies of behaviours that were indicative of effort and persistence in mathematics in all eight items compared to the average of their OECD and EU counterparts (Table 4.6). In Ireland, 81.9% of students felt that they paid attention when their mathematics teacher was speaking in more than half of the lessons. This was noticeably higher than the OECD (72.9%) and EU (70.5%) averages. Most students in Ireland indicated that they put effort into their assignments for mathematics class in more than half of the lessons (72.5%). This, again, was noticeably higher than the OECD (63.2%) and EU (58.9%) averages. In Ireland, similar proportions of students indicated that they actively participate in group discussions during mathematics class in fewer than half of lessons (37.5%) or in more than half of lessons (36.1%). The percentages of students who reported actively participating in such discussions in fewer than half of the lessons were somewhat higher across both the OECD (43.5%) and the EU (44.4%), on average, than in Ireland.

The overall trend across the items suggests that a greater proportion of students in Ireland perceive that they exhibit proactive mathematics study behaviours more frequently than across OECD and EU countries, on average.

Table 4.6 - Percentages of students reporting how often they engaged in behaviours indicative of effort and persistence in mathematics, in Ireland and at the OECD and EU averages

		Fewer than half of lessons	About half of the time	More than half of lessons
		%	%	%
I actively participated in group discussions during mathematics class.	Ireland	37.5	26.4	36.1
	OECD	43.5	23.9	32.6
	EU	44.4	23.7	31.9
I paid attention when my mathematics teacher was speaking.	Ireland	5.4	12.7	81.9
	OECD	10.5	16.7	72.9
	EU	11.8	17.7	70.5
I put effort into my assignments for mathematics class.	Ireland	9.5	17.9	72.5
	OECD	15.6	21.2	63.2
	EU	18.5	22.6	58.9
I made time to learn the material for mathematics class.	Ireland	25.1	26.0	48.9
	OECD	25.1	26.0	48.9
	EU	26.7	26.7	46.6
I asked questions when I did not understand the mathematics material that was being taught.	Ireland	29.1	22.8	48.2
	OECD	30.3	22.9	46.8
	EU	32.8	23.2	44.0
I lost interest during mathematics lessons.	Ireland	47.2	21.1	31.8
	OECD	47.6	22.2	30.2
	EU	46.6	22.4	31.0
I tried to connect new material to what I have learned in previous mathematics lessons.	Ireland	27.7	26.3	46.0
	OECD	27.7	26.7	45.6
	EU	28.6	26.8	44.5
I started my work on mathematics assignments right away.	Ireland	27.6	25.8	46.6
	OECD	28.9	25.5	45.6
	EU	30.6	25.3	44.2

Source: e-appendix Table A4.6

An index of proactive mathematics study behaviour was created by aggregating students' answers to the statements in Table 4.6. This index was standardised to have a mean of zero and a standard deviation of one across the 34 OECD countries. Ireland's average score on this index was 0.09, which is higher than both the OECD average of 0.00 and the EU average of -0.06, but the difference was not significant. This indicates that, on average, students in Ireland and across OECD and EU

countries, perceive that they engage in proactive mathematics behaviours to a similar extent. The highest performing country on this index across the OECD was the United States with a mean score of 0.27, with Denmark highest among EU countries (0.19). The lowest score across the OECD and EU was in Poland (-0.38).

In Ireland, there was a significant difference between the mean scores of male and female students on the index measuring proactive mathematics behaviours (Figure 4.5). On average, females reported higher levels of proactive mathematics study behaviours compared to their male counterparts (a significant gap of 0.10). While mean scores were different, the magnitude of gender differences on this index in Ireland was similar to those across the OECD and EU averages; these differences were also statistically significant.

Figure 4.5 - Mean scores on the index of proactive mathematics study behaviour, by gender, in Ireland and at the OECD and EU averages

Source: e-appendix Figure A4.5. Significant differences from the reference group are highlighted in bold.

4.5. Summary

This chapter examined the teaching and learning of mathematics in Ireland, analysing cognitive activation in mathematics lessons, creative pedagogies, mathematics teacher support, and student learning strategies. The findings are contextualised against the OECD and EU averages, complemented by detail on gender differences.

Students in Ireland reported high levels of cognitive activation, particularly regarding teacher behaviours that foster reasoning, such as asking students to justify answers and encouraging them to persevere with challenging mathematics tasks. The reports of students in Ireland regarding the extent of encountering these teaching behaviours exceeded both EU and OECD averages. With regards to teacher behaviours that encourage mathematical thinking, the reports of students in Ireland were broadly on a par with the average of their OECD and EU peers. However, there were higher reports of the teacher showing them how some problems that look difficult can be solved more easily by understanding how the number system is organised from students in Ireland, compared to their peers in the OECD and the EU. Male students in Ireland perceived higher exposure to teaching behaviours that fostered reasoning and encouraged mathematical thinking than female students, and the gender differences were more pronounced in Ireland than across the OECD and EU on average.

Most students in Ireland agreed that creativity is fostered and supported in their school and classes; the average score for Ireland on this index was above the corresponding OECD and EU averages. Students in Ireland were particularly likely to agree that original answers were encouraged, and that teachers value students' creativity. Gender comparisons in Ireland revealed no significant differences, contrasting with OECD and EU patterns where significant differences in favour of male students were found in terms of perceived support for creativity.

Students in Ireland consistently reported higher levels of support from teachers compared to EU and OECD peers. Behaviours such as providing help when needed and showing interest in student learning were reported at high frequencies. On average, male students in Ireland reported higher levels of perceived support from

teachers than females, aligning with similar gender differences observed at the OECD average.

In general, students in Ireland were less likely than their OECD and EU peers to agree that they engaged in self-regulation practices. On the other hand, they were somewhat more likely to report engaging in proactive study behaviours, such as paying attention in class and persisting with assignments. On average, females in Ireland reported engaging in these behaviours more frequently than males, a trend also observed across the OECD and the EU.

5. Students’ interaction with mathematics

This chapter presents a picture of students' interactions with mathematics by examining their levels of engagement with it as well as their familiarity with and their exposure to various aspects of mathematics. Engagement with mathematics includes principals' reports of the availability of additional mathematics lessons and mathematics-related extracurricular activities in schools, as well as students' own reports of their participation in additional mathematics classes. This chapter goes on to explore students' subjective familiarity with a range of mathematics concepts, as well as their self-reported exposure to two aspects of mathematics, formal and applied mathematics tasks, and mathematical reasoning and 21st century mathematics tasks. Data from Ireland are compared with the averages across OECD and EU countries, and, in the case of composite indices, are also analysed by gender.

5.1. Engagement with mathematics

Engagement with mathematics in PISA is measured both by principals' reports of the extent to which additional mathematics lessons are offered in their school and also by students' reports of the extent to which they participate in additional mathematics lessons. The availability of mathematics-related extracurricular activities in schools is another dimension of student engagement with mathematics measured by PISA and examined in this section.[4]

5.1.1. Availability of additional mathematics lessons – principals' reports

Schools were asked whether additional mathematics classes were offered to students apart from those offered during the usual school hours. In Ireland, 62.5% of students attended schools where the principal reported that the school offered additional mathematics lessons, the same as the OECD average of 62.5%, and slightly below the EU average of 66.7%.

[4] The data on availability of mathematics-related extracurricular activities in schools describe the extent to which schools offer these activities but does not describe the extent to which students participate in these activities.

The following analysis pertains to students attending schools whose principals reported that the school offered additional mathematics lessons. The principals in this subset of schools were also asked what type of additional mathematics classes were offered, from a list of three options: enrichment classes (that is, classes to support talented students), learning support classes, and classes without differentiation based on prior achievement (that is additional classes for a wider student group that are neither for enrichment or learning support) (Table 5.1 below). More students in Ireland (68.5%) attended schools that offered enrichment classes than on average across OECD and EU countries (60.3% and 57.5% respectively). Over 90% of students in Ireland attended schools that offered learning support classes for mathematics, slightly below the OECD and EU averages. Less than half of students across Ireland, the OECD and the EU attended schools that offered additional mathematics classes without differentiation based on prior achievement.

Table 5.1 - Percentages of students attending schools whose principal reported different types of additional mathematics lessons offered, in Ireland and at the OECD and EU averages

		Yes %	No %
Enrichment	Ireland	68.5	31.5
	OECD	60.3	39.7
	EU	57.5	42.5
Learning Support	Ireland	90.7	9.3
	OECD	92.7	7.3
	EU	92.4	7.6
Without differentiation depending on the prior achievement level of the students	Ireland	43.2	56.8
	OECD	47.7	52.3
	EU	46.0	54.0

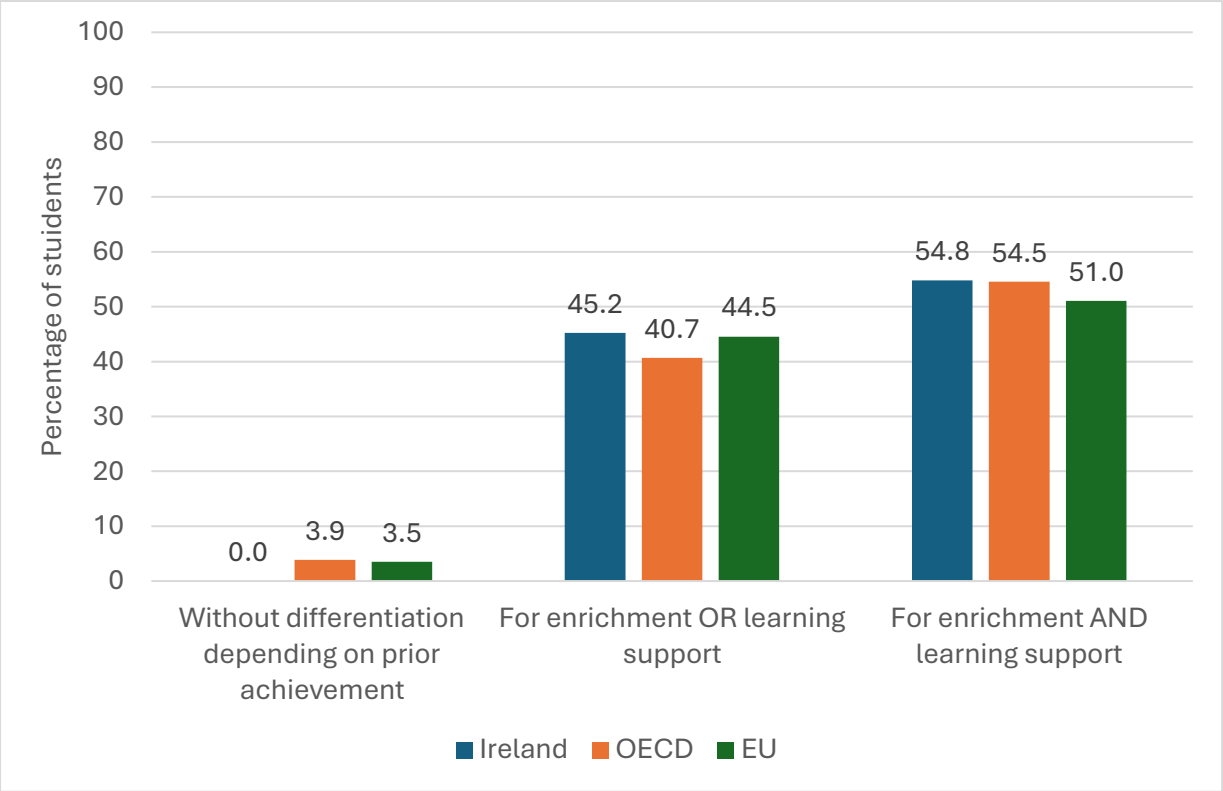
Source: e-appendix Table A5.1

Data from these questions were combined to create an index of mathematics extension courses offered at school. Based on their answers to the preceding questions, schools were assigned to one of three categories:

- schools that only offer additional mathematics classes without differentiation
- schools that offer *either* enrichment *or* learning support mathematics classes
- schools that offer *both* enrichment *and* learning support mathematics classes

Of those who attended schools that offered additional lessons in Ireland, 45.2% of students attended a school that offered additional mathematics classes for *either* enrichment *or* learning support purposes, compared with 44.5% across EU countries and 40.7% across OECD countries, on average (Figure 5.1). In Ireland, the remaining 54.8% attended a school that offered additional mathematics classes for *both* enrichment *and* learning support (compared with 51.0% across the EU and 54.5% across the OECD on average).

Figure 5.1 - Percentages of students attending schools that offered various categories of additional mathematics lessons, in Ireland and at the OECD and EU averages



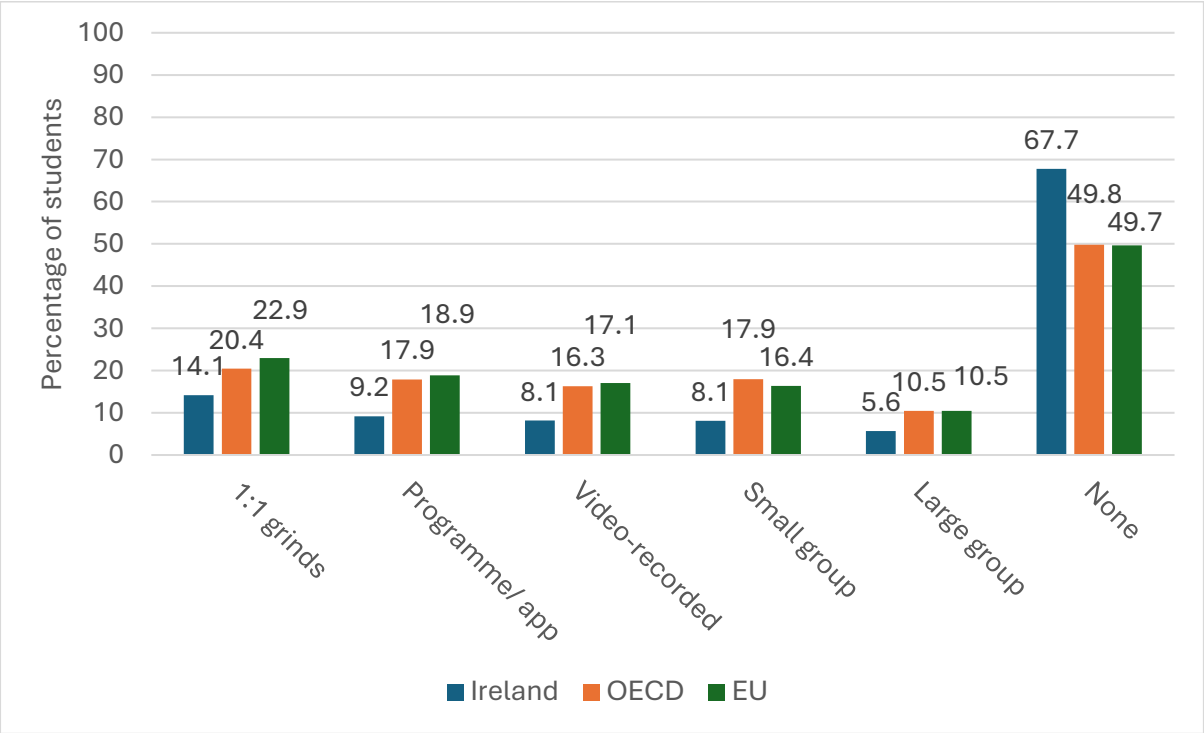
Source: e-appendix Figure A5.1

5.1.2. Participation in additional mathematics lessons – students' reports

Students were also asked about the extra mathematics tuition that they participated in. Figure 5.2 shows the proportion of students who participated in various types of extra mathematics tuition. The proportion of students in Ireland (67.7%) who reported that they did not participate in any additional mathematics instruction was higher than across OECD (49.8%) and EU (49.7%) countries, on average. One-to-

one grinds with a person was the most common type of extra mathematics tuition in Ireland, as well as across OECD and EU countries, on average. However, the percentage of students engaging in such additional lessons was lower in Ireland (14.1%) than on average across OECD or EU countries (20.4% and 22.9%, respectively). There were considerably lower levels of participation among students in Ireland (8.1%) in small group study or practice when compared with students across OECD (17.9%) and EU (16.4%) countries, on average. Similarly, almost twice as many students across EU and OECD countries, on average (10.5%) took part in large group study or practice compared to students in Ireland (5.6%). Students in Ireland also reported lower levels of participation in tutoring using an online or computer-based application, with only 9.2% reporting that they availed of such instruction in contrast to 17.9% across OECD countries and 18.9% across EU countries, on average.

Figure 5.2 - Percentages of students reporting that they received additional mathematics instruction, in Ireland and at the OECD and EU averages



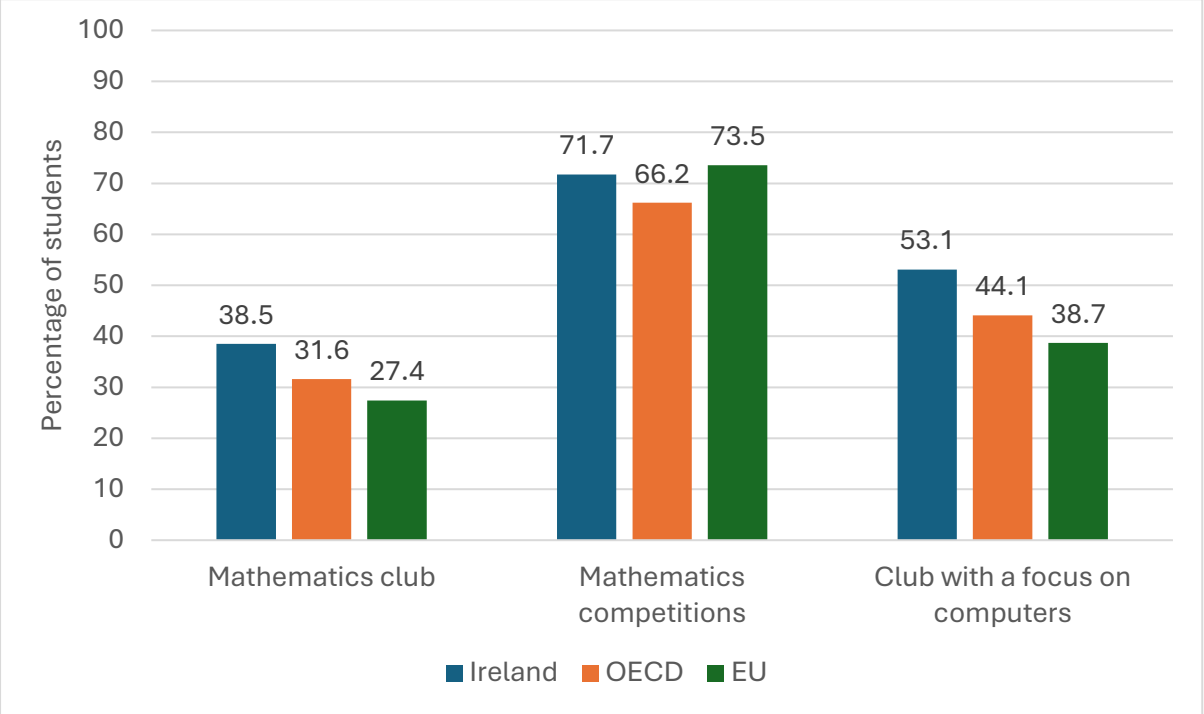
Source: e-appendix Figure A5.2

5.1.3. Availability of mathematics related extracurricular activities at school – principals' reports

Principals were also asked whether a range of extracurricular activities were offered to students in Third Year[5], including mathematics-related extracurricular activities such as a mathematics club, mathematics competitions, or a club with a focus on computers (e.g. programming or coding). Figure 5.3 shows the proportion of students in Ireland, and across OECD and EU countries, on average, attending schools which offered the various mathematics-related extracurricular activities. A greater percentage of students in Ireland attended schools that offered a mathematics club in comparison to the average of students across OECD and EU countries, and this was also the case for those attending schools that offer clubs with a focus on computers. For clarity, it should be noted that schools were asked which of the listed activities schools undertook with Third Years and does not provide a measure of the extent to which students participated in these activities. Over two-thirds of students in Ireland, and on average across OECD and EU countries, attended schools where mathematics competitions were offered. The most prominent example of this in Ireland would be the Irish Mathematics Olympiad which is intended for talented students and runs from October to December annually at six enrichment centres based in universities nationwide. No data was collected from students regarding their participation in mathematics related extracurricular activities.

[5] In each country, principals were asked to refer to the modal PISA grade in their country (i.e., the grade in which most PISA students are enrolled in). In Ireland, principals were asked to refer to students in Third Year.

Figure 5.3 - Percentages of students whose school principals reported that certain mathematics-related extra-curricular activities are offered to Third Year students in their school, in Ireland and at the OECD and EU averages



Source: e-appendix Figure A5.3

5.2. Familiarity with and exposure to mathematical concepts

The following section examines data from students' own reports of how familiar they are with a range of mathematical concepts, as well as their reports of the frequency with which they have encountered a range of mathematical tasks.

5.2.1. Subjective familiarity with mathematics concepts – students' reports

Students were asked about the degree to which they were familiar with a range of ten mathematical concepts representative of different levels of mathematical skill or understanding, with response options ranging from 'never heard of it' to 'know it well' (Table 5.2). It should be emphasised that this index is based on students' subjective reports of how familiar they were with these concepts, as opposed to students being independently assessed on them, or their familiarity being evaluated by a teacher.

Table 5.2 - Percentages of students reporting how familiar they were with different mathematical concepts representative of different levels of mathematical skill or understanding, in Ireland and at the OECD and EU averages

		Rarely or never heard of it	Heard of it a few times	Heard of it often or know it well
		%	%	%
Divisor	Ireland	49.8	19.4	30.8
	OECD	22.3	13.3	64.4
	EU	19.7	12.0	68.2
Area of a circle	Ireland	5.3	11.6	83.1
	OECD	9.5	14.8	75.7
	EU	8.7	14.3	76.9
Congruent figures	Ireland	47.1	24.7	28.2
	OECD	33.8	20.9	45.4
	EU	32.6	20.4	47.0
Linear equation	Ireland	6.9	11.2	81.9
	OECD	15.8	16.5	67.7
	EU	14.3	16.1	69.7
Pythagorean theorem	Ireland	13.3	11.0	75.8
	OECD	9.7	11.7	78.6
	EU	8.0	10.3	81.7
Linear inequalities	Ireland	19.1	20.2	60.7
	OECD	26.3	20.9	52.8
	EU	22.9	20.0	57.1
Complex number	Ireland	45.2	24.0	30.8
	OECD	43.1	23.1	33.8
	EU	44.9	23.5	31.5
Exponential function	Ireland	41.4	19.8	38.8
	OECD	44.6	21.2	34.2
	EU	48.6	20.7	30.8
Probability	Ireland	3.9	6.9	89.2
	OECD	14.9	16.3	68.7
	EU	16.3	17.4	66.3
3-dimensional geometry	Ireland	44.8	23.0	32.1
	OECD	39.7	21.4	38.9
	EU	38.6	20.7	40.7

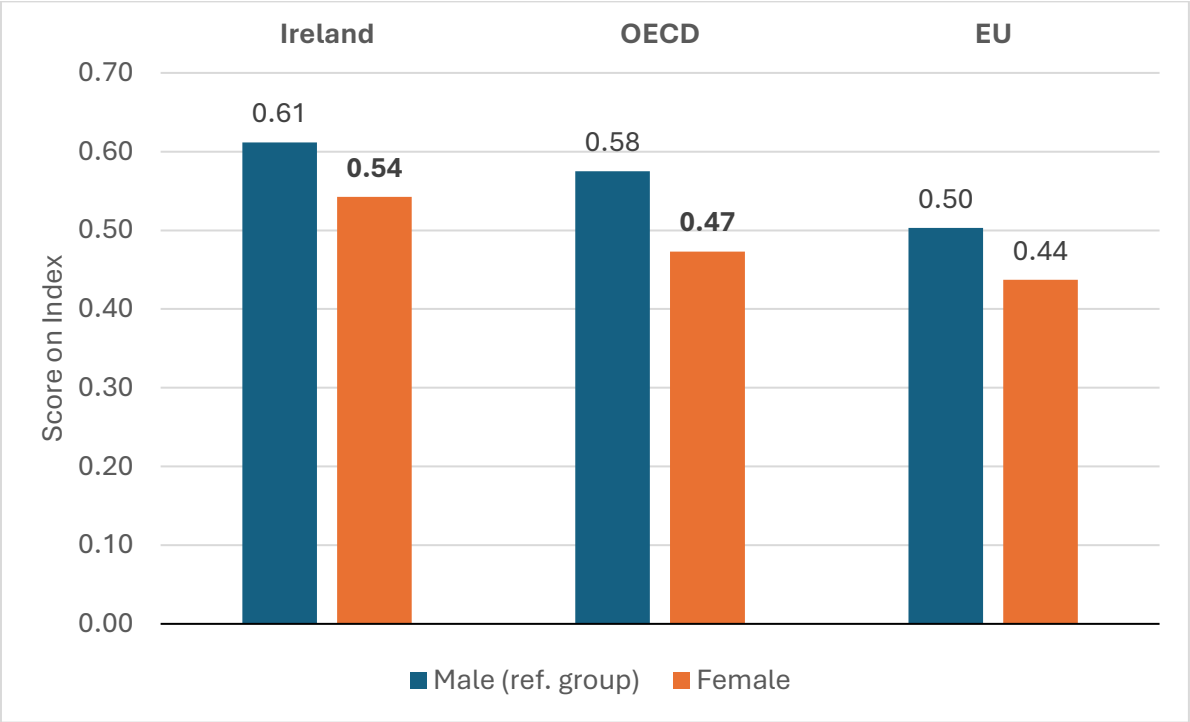
Source: e-appendix Table A5.2

There was variation in the extent to which students in Ireland were familiar with the concepts, relative to their peers across OECD and EU countries, on average. Across five of the concepts – area of circle, linear equation, linear inequalities, exponential functions and probability – students in Ireland reported higher levels of familiarity than OECD and EU students, on average. This was most notable for the concept of probability, with 89.2% of students in Ireland reporting that they heard of it often or know it well, compared to 67.8% at the OECD average and 66.3% at the EU average. On average across OECD and EU countries, students reported higher levels of familiarity than students in Ireland across the remaining concepts. The gap was most pronounced for the concept of a divisor, with only 30.8% of students in Ireland reporting they heard of it often or know it well in contrast to 64.4% across OECD countries and 68.2% across EU countries, on average. It should be noted that PISA 2022 testing took place early in the 2022/2023 academic year, and while the majority of the students who took part in PISA 2022 in Ireland were in Transition Year (57%), a sizeable proportion (26%) were in Third Year.

The responses to these questions were scaled into the index of subjective familiarity with mathematics concepts. The index was scaled to a mean of zero and a standard deviation of one on average across all participating OECD countries in 2012. The mean score for Ireland (0.58) was higher than the mean score across OECD (0.52) and EU (0.47) countries, which indicates that students in Ireland, on average, felt they were more familiar with these concepts overall than students across OECD and EU countries did. Internationally, Korea reported a mean of 2.15 on this index, substantially higher than all other countries in the OECD, indicating very high levels of familiarity with these concepts among students in Korea.

On average, male students scored higher on the index of subjective familiarity with mathematics concepts than female students in Ireland, and a gap of similar direction and magnitude was apparent across OECD and EU countries, on average (Figure 5.4). In the case of Ireland and the OECD average, the differences were statistically significant.

Figure 5.4 - Mean scores on the index of subjective familiarity with mathematics concepts, by gender, in Ireland and at the OECD and EU averages



Source: e-appendix Figure A5.4. Significant differences from the reference group are highlighted in bold.

5.2.2. Exposure to mathematics – students' reports

Two aspects of students' exposure to mathematics are examined: their exposure to formal and applied mathematics, as well as their exposure to mathematical reasoning and 21st century mathematics tasks.

5.2.2.1. Exposure to formal and applied mathematics

Students were presented with a range of formal and applied mathematics tasks and asked about the frequency with which they had come across these tasks, with four options ranging from frequently to never. Among others, this included tasks such as calculating how much more expensive a computer would be after adding VAT and understanding scientific tables presented in an article (Table 5.3).

Table 5.3 - Percentages of students reporting how often they had encountered a range of formal and applied mathematics tasks during their time at school, in Ireland and at the OECD and EU averages

		Frequently %	Sometimes %	Rarely or Never %
Working out from a train timetable how long it would take to get from one place to another	Ireland	15.3	43.6	41.1
	OECD	17.0	36.9	46.1
	EU	17.6	36.8	45.6
Calculating how much more expensive a computer would be after adding tax	Ireland	22.2	46.6	31.2
	OECD	15.3	34.9	49.8
	EU	16.4	35.4	48.2
Calculating how many square metres of tiles you need to cover a floor	Ireland	23.7	47.2	29.0
	OECD	22.3	39.9	37.8
	EU	24.4	39.8	35.8
Understanding scientific tables presented in an article	Ireland	15.2	41.8	43.0
	OECD	14.0	34.6	51.3
	EU	14.7	34.7	50.7
Solving an equation like $6x^2+5 = 29$	Ireland	63.9	24.8	11.3
	OECD	56.9	27.8	15.3
	EU	58.3	26.8	14.9
Finding the actual distance between two places on a map with a 1:10,000 scale	Ireland	13.7	39.6	46.7
	OECD	15.3	33.6	51.2
	EU	15.5	34.2	50.3
Solving an equation like $2(x+3) = (x+3)(x-3)$	Ireland	66.7	23.1	10.2
	OECD	59.6	26.2	14.2
	EU	60.8	25.4	13.9
Calculating the power consumption of an electronic appliance per week	Ireland	11.2	34.7	54.2
	OECD	11.4	28.3	60.3
	EU	11.9	28.7	59.4
Solving an equation like $3x+5=17$	Ireland	68.0	22.2	9.8
	OECD	59.9	25.6	14.5
	EU	61.3	24.3	14.4

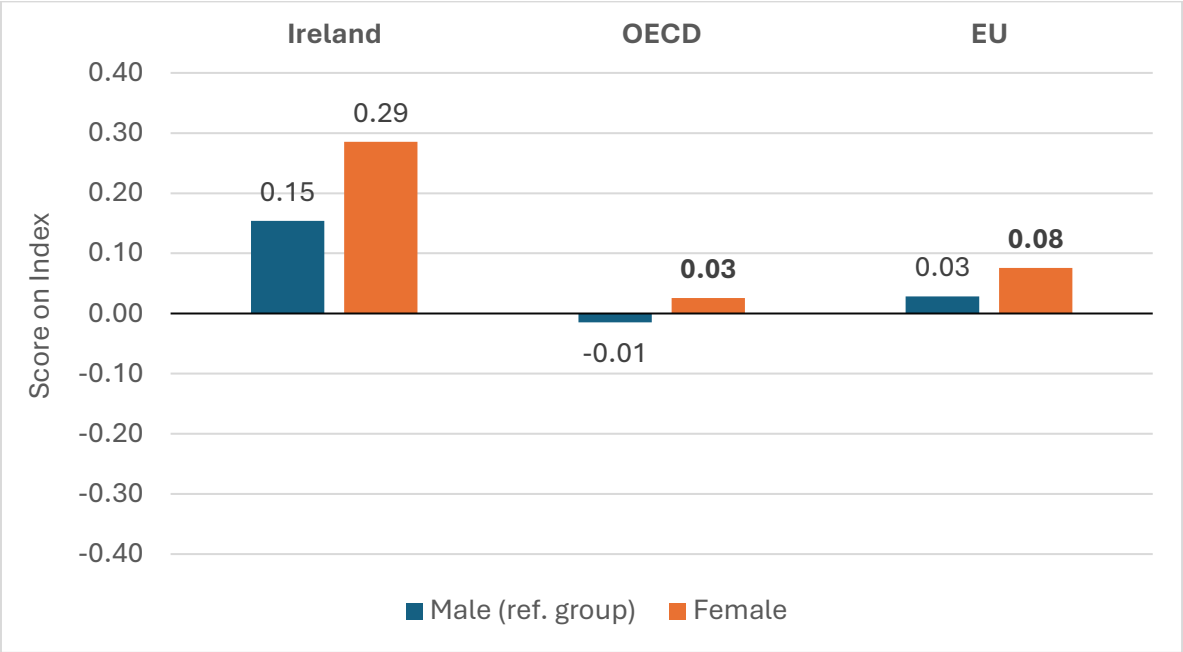
Source: e-appendix Table A5.3

Table 5.3 illustrates the frequency with which students in Ireland reported encountering these tasks relative to students across the EU and OECD on average. About two-thirds of students in Ireland reported frequent exposure to linear and quadratic equations, somewhat higher than the corresponding percentages for the averages of their OECD and EU peers. These three algebra-related tasks are more

formal than applied tasks. The percentages of students in Ireland who reported being asked on a frequent basis to calculate how much more expensive a computer would be after adding tax was much lower, at 22.2%, although still above the corresponding OECD (15.3%) and EU (16.4%) averages. On the other hand, students in Ireland were less likely, albeit just slightly, than their OECD and EU peers, on average, to be asked to work out a distance on a map or the travel time from a train timetable. It should be noted that this data is based on student reports and does not necessarily reflect the frequency with which these tasks have been taught in the classroom.

The data from these questions were combined to create an index of exposure to formal and applied mathematics tasks. The index was scaled to a mean of zero and a standard deviation of one on average across all participating OECD countries. The mean score for Ireland (0.22) was higher than the mean score across OECD (0.01) and EU (0.05) countries, suggesting that overall students in Ireland reported noticeably higher levels of exposure to these tasks than OECD and EU students, on average. Internationally, Denmark had the highest mean score on this index (0.40) and also had a mathematics achievement score above the OECD average in PISA 2022. However, Korea's score on this index (-0.52) was the second lowest in the OECD after Italy (-0.55), countries with mathematics achievement scores in PISA 2022 substantially above, and at the OECD average, respectively. In Ireland, and across EU and the OECD countries, on average, female students had higher mean scores on the index than male students did (Figure 5.5). While the gender difference in Ireland was larger than at the OECD and EU averages, it was not statistically significant.

Figure 5.5 - Mean scores on the index of exposure to formal and applied mathematics tasks, by gender, in Ireland and at the OECD and EU averages



Source: e-appendix Figure A5.5. Significant differences from the reference group are highlighted in bold.

5.2.2.2. Exposure to mathematical reasoning and 21st century mathematics tasks

Students were also asked to report the frequency with which they had encountered a range of mathematical reasoning and 21st century mathematics tasks, with four options ranging from frequently to never (Table 5.4). Tasks included interpreting mathematical solutions in the context of a real-life challenge and evaluating the significance of observed patterns in data. Across seven of the ten items, students in Ireland reported higher levels of frequent exposure to these tasks than their OECD or EU peers, on average. The difference was most pronounced in relation to extracting mathematical information from diagrams, graphs, or simulations with 47.0% of students in Ireland having encountered this task frequently compared to 34.6% across OECD countries and 34.4% across EU countries, on average. Two of the three tasks in which a lower proportion of students in Ireland reported having encountered them frequently related to computers. The largest difference is for working with computer mathematics systems, such as spreadsheets and programming software, with 11.2% having come across this task frequently in Ireland

compared to 18.7% across OECD countries and 18.4% across EU countries, on average.

Table 5.4 - Percentages of students reporting how often they had encountered a range of mathematical reasoning and 21st century mathematics tasks during their time at school, in Ireland and at the OECD and EU averages

		Frequently %	Sometimes %	Rarely or Never %
Extracting mathematical information from diagrams, graphs, or simulations	Ireland	47.0	42.4	10.6
	OECD	34.6	41.0	24.4
	EU	34.4	41.1	24.5
Interpreting mathematical solutions in the context of a real-life challenge	Ireland	20.2	47.0	32.8
	OECD	19.7	39.6	40.7
	EU	19.3	38.8	41.9
Using the concept of statistical variation to make a decision	Ireland	16.9	48.5	34.6
	OECD	14.4	36.4	49.2
	EU	13.4	35.1	51.4
Identifying mathematical aspects of a real-world problem	Ireland	18.2	45.3	36.5
	OECD	17.1	38.4	44.5
	EU	15.6	37.6	46.8
Identifying constraints and assumptions behind mathematical modelling	Ireland	11.9	40.9	47.2
	OECD	13.9	37.7	48.4
	EU	13.2	37.1	49.6
Representing a situation mathematically using variables, symbols, or diagrams	Ireland	39.8	43.3	16.9
	OECD	31.2	40.4	28.3
	EU	29.1	40.9	30.0
Evaluating the significance of observed patterns in data	Ireland	21.7	48.9	29.4
	OECD	17.8	39.4	42.8
	EU	15.8	38.3	46.0
Coding/programming computers	Ireland	5.8	19.3	74.9
	OECD	8.6	20.6	70.8
	EU	8.8	21.1	70.1
Working with computer mathematics systems (e.g. spreadsheets, programming software, graphing calculators)	Ireland	11.2	29.1	59.7
	OECD	18.7	32.3	49.0
	EU	18.4	31.6	50.0
Calculating the properties of an irregularly shaped object	Ireland	18.6	46.8	34.6
	OECD	17.6	37.9	44.5
	EU	16.6	37.4	46.0

Source: e-appendix Table A5.4

An index of exposure to mathematical reasoning and 21st century mathematics tasks was created using the data from these questions. The index was scaled to a mean of zero and a standard deviation of one across all participating OECD countries. The mean score for Ireland (0.19) was higher than the mean score across EU (-0.03) and OECD (0.01) countries, pointing to higher levels of reported exposure to these tasks among students in Ireland, consistent with the picture painted by the individual questions. Internationally, high achieving Denmark and Korea recorded the highest (0.40) and lowest (-0.45) scores respectively across the OECD on this index.

Gender differences on this index were small and not statistically significant in Ireland or at the OECD average (Figure 5.6). On average across EU countries, however, male students had a significantly higher mean score on this index, indicating higher levels of reported exposure to mathematical reasoning and 21st Century skills among EU males than females, on average.

Figure 5.6 - Mean scores on the index of exposure to mathematical reasoning and 21st century mathematical tasks, by gender, in Ireland and at the OECD and EU averages

Source: e-appendix Figure A5.6. Significant differences from the reference group are highlighted in bold.

5.3. Summary

This chapter examined elements of student engagement with mathematics, including availability and engagement in additional mathematics lessons and mathematics-related extracurricular activities, and the extent to which students are familiar with and had encountered a range of mathematical concepts and tasks during their time at school.

The proportion of students in Ireland attending schools that offered additional mathematics lessons was on a par with the averages across OECD and EU countries. Of those who attended schools that offered such lessons, the vast majority were in schools that offered additional mathematics lessons for learning support. A somewhat higher proportion of students in Ireland attended schools that also offered additional mathematics lessons for enrichment relative to their peers across OECD and EU countries, on average. Nonetheless, over two thirds of students in Ireland reported that they did not participate in additional mathematics lessons, compared to just under half of students across OECD and EU countries, on average. One-on-one grinds in person was the additional support most frequently reported to be received. While school reports of mathematics-related extracurricular activities indicate moderate to high levels of activities being offered by schools, no data is available on the extent to which students participate in these activities.

The data in relation to student reports of their familiarity with mathematics concepts presents a mixed picture. In some instances, particularly in the case of probability, students in Ireland reported substantially higher levels of familiarity with the concept than on average across OECD and EU countries. On the other hand, students in Ireland reported being much less familiar with divisors and congruent figures, and somewhat less familiar with three-dimensional geometry, than their OECD and EU peers, on average. Overall students in Ireland reported very slightly higher levels of familiarity with the mathematics concepts presented and male students also tended to report slightly higher levels of familiarity than female students did, in Ireland and on average across OECD and EU countries.

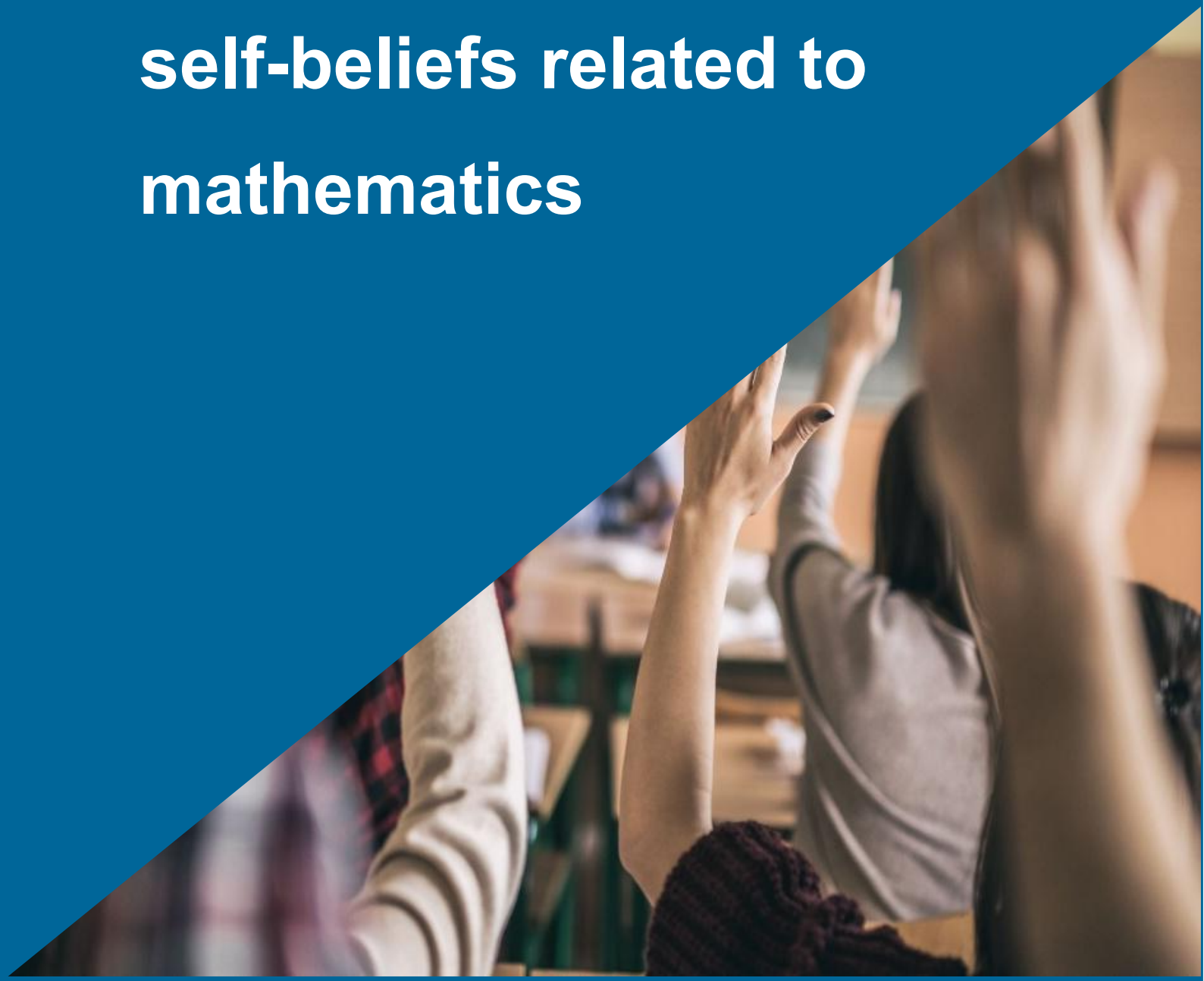
In relation to the frequency with which students have come across specific formal and applied mathematics tasks, students in Ireland generally reported higher levels of exposure to these tasks relative to their peers across OECD and EU countries. In

Ireland and internationally, females reported having come across these tasks at higher levels than males, and while the difference was higher in Ireland than internationally, it was not statistically significant. In particular, students in Ireland reported greater levels of exposure to linear and quadratic equations than the average across OECD and EU countries.

Across many of the mathematical reasoning and 21st century mathematics tasks, students in Ireland reported higher levels of exposure than their OECD and EU peers on average, particularly in relation to extracting mathematical information from diagrams and graphs. Interestingly, students in Ireland reported lower frequencies of exposure to computer-related tasks compared to students across the OECD and EU. Gender differences on this index were small and not statistically significant in Ireland or at the OECD average, although, on average across EU countries, males reported significantly greater levels of exposure than female students.

Foras Taighde ar Oideachas
Educational Research Centre

6. Students' attitudes and self-beliefs related to mathematics



This chapter examines various dimensions of students' attitudes and feelings towards mathematics as measured by PISA. It looks at students' motivation to excel in mathematics relative to other core subjects, their relative enjoyment and ease with the subject, as well as the extent to which students experience mathematics-related anxiety. Additionally, it analyses their self-efficacy in tackling both formal and applied mathematical tasks, as well as tasks associated with mathematical reasoning and 21st-century skills. The responses of students in Ireland are compared with their peers across OECD and EU countries, and gender differences in attitudes and self-beliefs are also outlined.

6.1. Attitudes towards learning mathematics

Students' attitudes towards learning mathematics are measured in PISA through students' reports of their preference for mathematics over other core subjects, whether they perceive mathematics as easy, and their motivation to do well in mathematics. As well as being reported in overall terms, these attitudes are also reported relative to the corresponding reports for selected core subjects – English[6] and science – and are discussed in the following sections.

6.1.1. Motivation to do well in mathematics

Students were asked the extent to which they agreed with the statement "I want to do well in my mathematics class". In Ireland, 94.3% of students agreed or strongly agreed with this statement, compared to 89.3 % across OECD countries and 87.0% across EU countries, on average (see e-appendix Table A6.1).

Students' responses to this statement were compared to the same statement about English and science to assess their relative motivation to do well in mathematics compared to other core subjects[7]. The index of relative motivation to do well in mathematics compared to other core subjects shows that 3.6% of students in Ireland reported that they were more motivated to succeed in mathematics than in English or

[6] The core language subject asked about varied by country. For ease of reporting, the core language subject is referred to as English throughout this chapter.
[7] Students were assigned a score of 1 if they expressed stronger agreement with the statement "*I want to do well in my mathematics class"* than with both corresponding statements about English and science. If this was not the case, they received a score of 0.

science class (Table 6.1). This percentage was slightly lower than the percentages across OECD (5.4%) and EU (5.7%) countries, on average. In Ireland, the proportion of male students (4.6%) who felt more motivated to do well in mathematics class than in other core subjects was slightly higher than the proportion of female students who felt this way (2.6%). The average gender differences across OECD and EU countries were of a similar magnitude, with male students more motivated than female students to do well in mathematics compared to other subjects.

Table 6.1 – Percentages of students who are more motivated to do well in mathematics than in English and science class, by gender, in Ireland and at the OECD and EU averages

	Overall %	Male %	Female %
Ireland	3.6	4.6	2.6
OECD	5.4	6.7	4.2
EU	5.7	7.1	4.3

Source: e-appendix Table A6.2. Note: The core language assessed in Ireland was English, but this varies by country.

6.1.2. Perception of mathematics as easy

Students were asked about the extent to which they agreed that mathematics was easy for them. In Ireland 40.1% of students strongly agreed or agreed that mathematics was easy for them (see e-appendix Table 6.0). This was slightly lower than the percentages across the OECD (43.7%) and the EU (42.5%) on average. The extent to which students perceive mathematics as being easier than other core subjects was measured by comparing students' responses to this statement with the same statement about English and science.[8]

The findings suggest that a smaller percentage of students in Ireland (7.7%) perceive mathematics as being easier than other core subjects compared to the percentage of students across OECD (12.0%) and EU (11.5%) countries, on average (Table 6.2). Slightly more male students in Ireland (8.5%) viewed mathematics as easier than their other core subjects when compared with their female counterparts

[8] Similarly to previously, if a student had a higher level of agreement to the statement about mathematics being easy for them than they did on the corresponding statement for the other core subjects, they received a score of one indicating a "*perception of mathematics as easier*", otherwise they received a score of zero representing "*no perception of mathematics as easier*".

(6.8%). On average across OECD and EU countries, the gender difference was greater, with 14.1% of males and 10.0% of females indicating that they find mathematics easier than other subjects.

Table 6.2 – Percentages of students who perceive mathematics as easier than English and science, by gender, in Ireland and at the OECD and EU averages

	Overall %	Male %	Female %
Ireland	7.7	8.5	6.8
OECD	12.0	14.1	10.0
EU	11.5	13.5	9.6

Source: e-appendix Table A6.3. Note: The core language assessed in Ireland was English, but this varies by country.

6.1.3. Preference for mathematics

Students were also asked about the extent to which they agreed that mathematics was one of their favourite subjects. In Ireland, 35.8% of students strongly agreed or agreed that mathematics was one of their favourite subjects (Table 6.3). This percentage was slightly lower than the average across OECD countries (39.4%), and similar to the EU average (36.1%).

Table 6.3 – Percentages of students agreeing that mathematics is one of their favourite subjects in Ireland and at the OECD and EU averages

	Strongly Agree or Agree %	Strongly Disagree or Disagree %
Ireland	35.8	64.2
OECD	39.4	60.6
EU	36.1	63.9

Source: e-appendix Table A6.4. Note: The core language assessed in Ireland was English, but this varies by country.

Students were also asked about the extent to which they agreed that English and science (other core subjects) were among their favourite subjects. With this data, an index of relative preference of mathematics over other core subjects was created,

reflecting students' preference for mathematics compared to the other two subjects.[9] In Ireland, 10.4% of students (Table 6.4) indicated that they had a preference for mathematics over English and science, which was lower than at the OECD (14.3%) and EU (13.4%) averages.

When looking at gender differences, there was a greater percentage of male students (12.3%) than female students (8.4%) in Ireland who indicated a preference for mathematics over English and science. Moreover, a similar gap was also observed on average across OECD and EU countries, with male students tending to show a greater preference for mathematics over English and science than their female counterparts.

Table 6.4 – Percentages of students reporting a preference for mathematics over English and science, by gender, in Ireland and at the OECD and EU averages

	Overall	Male	Female
	%	%	%
Ireland	10.4	12.3	8.4
OECD	14.3	16.1	12.6
EU	13.4	15.2	11.7

Source: e-appendix Table A6.5

6.2. Mathematics anxiety

Students were asked about their levels of agreement with a series of six statements about their feelings and emotional responses towards mathematics. These feelings and emotional responses were indicative of anxiety towards mathematics, for example, concerns about performance, feelings of helplessness, and nervousness during tasks. Students rated their agreement with statements via four response options ranging from strongly agree to strongly disagree.

In Ireland, 63.6% of students in Ireland agreed that they were often worried about mathematics classes being difficult for them, which was higher than the percentages

[9] Students were assigned a score of 1 if they indicated a higher level of agreement with the statement *"Mathematics is one of my favourite subjects"* than they did for the corresponding statements about science and English.

at the OECD (59.8%) and EU (57.9%) averages (Table 6.5). Similarly, the majority of students in Ireland also felt anxious about failing in mathematics (61.2%). This was considerably higher than corresponding percentages of students on average across OECD (54.8%) and EU (51.5%) countries. On the other hand, lower proportions of students in Ireland reported feeling nervous (34.1%) or helpless (36.9%) when doing mathematics problems compared to the corresponding percentages across the OECD (38.6% and 41.0% respectively) and EU (38.4% and 40.2% respectively), on average.

Table 6.5 – Percentages of students reporting levels of agreement with various statements relating to mathematics anxiety, in Ireland and at the OECD and EU averages

		Strongly Agree or Agree %	Strongly Disagree or Disagree %
I often worry that it will be difficult for me in mathematics classes.	Ireland	63.6	36.4
	OECD	59.8	40.2
	EU	57.9	42.1
I get very tense when I have to do mathematics homework.	Ireland	39.2	60.8
	OECD	39.4	60.6
	EU	37.5	62.5
I get very nervous doing mathematics problems.	Ireland	34.1	65.9
	OECD	38.6	61.4
	EU	38.4	61.6
I feel helpless when doing a mathematics problem.	Ireland	36.9	63.1
	OECD	41.0	59.0
	EU	40.2	59.8
I worry that I will get poor grades in mathematics.	Ireland	67.7	32.3
	OECD	64.9	35.1
	EU	61.9	38.1
I feel anxious about failing in mathematics.	Ireland	61.2	38.8
	OECD	54.8	45.2
	EU	51.5	48.5

Source: e-appendix A6.6

The data from responses to these items were combined to create the index of mathematics anxiety. This index was first introduced in PISA 2012 and was scaled to have a mean of zero and a standard deviation of one across the OECD countries that took part in that cycle. Ireland had a mean score of 0.21 on the index, which is significantly higher than the mean score of 0.17 across OECD countries and 0.12

across EU countries. This indicates that students in Ireland are slightly more likely to experience anxiety related to mathematics than students across the OECD on average, and somewhat more likely than students across the EU on average.

When analysed by gender, large differences emerge. Female students in Ireland had a mean score on the index of 0.50, which was substantially and significantly higher than the mean score of -0.08 recorded for male students (Figure 6.1). This points to elevated levels of mathematics anxiety among female students in Ireland. The gender difference among students across OECD countries and across EU countries also show higher levels of mathematics anxiety, on average, among female students. While these gender differences are slightly less pronounced than in Ireland, they are also statistically significant.

Figure 6.1 – Mean scores on the index of mathematics anxiety, by gender, in Ireland and at the OECD and EU averages

Source: e-appendix Figure A6.1. Significant differences from the reference group are highlighted in bold.

Ireland's mean score of 0.21 on the index of mathematics anxiety in PISA 2022 was higher than in PISA 2012, when the mean score for Ireland was 0.11, meaning that students in Ireland in 2022 are reporting higher levels of mathematics anxiety than

their counterparts in 2012. The increase in Ireland, however, was smaller than the corresponding increase across the OECD (from a mean score of 0.00 in 2012 to 0.17 in 2022).

Five of the six items that make up the mathematics anxiety index were common to the index in 2012 and 2022. For all but one of these statements, more students in Ireland agreed or agreed strongly in 2022 compared to 2012 (Table 6.6). The increase was most pronounced for I feel helpless when doing a mathematics problem from 28.0% in 2012 to 36.9% in 2022. Generally, the increase in the proportion of students agreeing with these statements about mathematics anxiety was higher across OECD and EU countries, on average, than in Ireland. However, the increase was slightly higher in Ireland for agreement with the statement I worry that I will get poor grades in mathematics. On the other hand, fewer students in Ireland agreed or strongly agreed with the statement that I often worry that it will be difficult for me in mathematics classes in 2022 (63.6%) than in 2012 (69.8%).

Table 6.6 – Percentages of students who agreed or strongly agreed with various statements about attitudes towards mathematics, in Ireland and at the OECD and EU averages, in 2012 and 2022

		2012 %	2022 %
I often worry that it will be difficult for me in mathematics classes.	Ireland	69.8	63.6
	OECD	59.8	59.8
	EU	59.5	57.7
I get very tense when I have to do mathematics homework.	Ireland	36.0	39.2
	OECD	33.5	39.4
	EU	30.8	37.2
I get very nervous doing mathematics problems.	Ireland	29.7	34.1
	OECD	31.3	38.6
	EU	31.1	37.9
I feel helpless when doing a mathematics problem.	Ireland	28.0	36.9
	OECD	29.8	41.0
	EU	30.8	40.1
I worry that I will get poor grades in mathematics.	Ireland	62.1	67.7
	OECD	63.0	64.9
	EU	60.4	61.5

Source: e-appendix A6.7

6.3. Mathematics self-efficacy

Students' levels of self-efficacy are measured in PISA by asking students to rate their confidence in performing a range of tasks grouped into formal and applied mathematics tasks or mathematical reasoning and 21st century mathematics tasks.

6.3.1. Self-efficacy related to formal and applied mathematics

Students were asked to report their level of confidence in tackling a range of formal and applied mathematical tasks, using four options ranging from not at all confident to very confident (Table 6.7). Tasks included, among others, calculating travel time using a timetable, and determining the amount of tax on an item.

A high proportion of students in Ireland (81.8%) felt confident or very confident about working out from a train timetable how long it would take to get from one place to another (Table 6.7). This was noticeably higher than both the OECD and EU averages of 67.3% and 67.1% respectively. Students in Ireland were also much more likely to report feeling confident or very confident when it came to calculating how much more expensive a computer would be after adding tax (74.6%) compared to the average of students across OECD (59.8%) and EU (60.3%) countries. On the other hand, 46.9% of students in Ireland reported feeling confident or very confident calculating the actual distance between two points on a scaled map, which was slightly lower than the corresponding percentages at the OECD (49.4%) and EU (51.8%) averages.

Table 6.7 – Percentages of students reporting levels of confidence about a range of formal and applied mathematics tasks, in Ireland and at the OECD and EU averages

		Not at all confident/Not very confident	Confident/Very confident
		%	%
Working out from a train timetable how long it would take to get from one place to another	Ireland	18.2	81.8
	OECD	32.7	67.3
	EU	32.9	67.1
Calculating how much more expensive a computer would be after adding tax	Ireland	25.4	74.6
	OECD	39.7	59.8
	EU	40.2	60.3
Calculating how many square metres of tiles you need to cover a floor	Ireland	29.2	70.8
	OECD	38.1	61.9
	EU	38.7	61.3
Understanding scientific tables presented in an article	Ireland	45.5	54.5
	OECD	45.8	54.2
	EU	43.9	56.1
Solving an equation like $6x^2+5=29$	Ireland	34.0	66.0
	OECD	29.2	70.8
	EU	29.5	70.5
Finding the actual distance between two places on a map with a 1:10,000 scale	Ireland	53.1	46.9
	OECD	50.6	49.4
	EU	48.2	51.8
Solving an equation like $2(x+3) = (x+3)(x-3)$	Ireland	32.6	67.4
	OECD	30.2	69.8
	EU	29.9	70.1
Calculating the power consumption of an electronic appliance per week	Ireland	48.5	51.5
	OECD	51.8	48.2
	EU	50.6	49.4
Solving an equation like $3x+5=17$	Ireland	22.1	77.9
	OECD	21.6	78.4
	EU	21.5	78.5

Source: e-appendix A6.8

The data from these responses were amalgamated to create the index of mathematics self-efficacy in formal and applied mathematics. This index was first introduced in PISA 2012 and was scaled to have a mean of zero and a standard deviation of one across the OECD countries that participated in that cycle. In PISA 2022, Ireland had a mean score of -0.26 on the index compared to a mean score of -0.37 across OECD countries and -0.35 across EU countries. These data suggest

that, on average, students in Ireland are somewhat more confident in tackling this range of formal and applied mathematical tasks than their peers across the OECD and EU.

A significant difference between male and female students in Ireland was observed on this index with female students, on average, reporting substantially lower levels of self-efficacy than their male counterparts (Figure 6.2). These differences were statistically significant. On average, female students across both OECD and EU countries reported even lower levels of mathematics self-efficacy than their female peers in Ireland. The gender differences across the OECD and EU were of a similar magnitude to those in Ireland and were also statistically significant.

Figure 6.2 – Mean scores on the index of self-efficacy in formal and applied mathematics, by gender, in Ireland and at the OECD and EU averages

Source: e-appendix A6.2. Significant differences from the reference group are highlighted in bold.

Ireland's mean score of -0.26 on the index of self-efficacy in formal and applied mathematics in PISA 2022 was substantially lower than in PISA 2012, when the mean score for Ireland was 0.01, meaning that students in Ireland in 2022 are

reporting lower levels of mathematics self-efficacy than students in Ireland in 2012. The decline in Ireland was smaller than at the OECD average, which declined from a mean score of 0.00 in 2012 to -0.37 in 2022.

Five of the nine items that make up the self-efficacy in formal and applied mathematics were common to the index in 2012[10] and 2022. For four of these formal and applied mathematics tasks, fewer students in Ireland reported being confident or very confident in 2022 compared to 2012. The decline was most pronounced for solving an equation like 2(x+3) = (x+3)(x-3), for which there was a 5.2 percentage point decline between 2012 and 2022. This was the only item where the decline was larger in Ireland than at the OECD (3.3 percentage points) and EU (2.9 percentage points) averages.

Table 6.8 – Percentages of students who were very confident or confident about a range of formal and applied mathematics tasks, in Ireland and at the OECD and EU averages, in 2012 and 2022.

		2012 %	2022 %
Working out from a train timetable how long it would take to get from one place to another	Ireland	85.9	81.8
	OECD	80.3	67.3
	EU	80.6	66.8
Calculating how many square metres of tiles you need to cover a floor	Ireland	69.2	70.8
	OECD	67.2	61.3
	EU	68.7	61.9
Finding the actual distance between two places on a map with a 1:10,000 scale	Ireland	48.7	46.9
	OECD	55.1	49.4
	EU	58.9	51.5
Solving an equation like 2(x+3) = (x+3)(x-3)	Ireland	72.6	67.4
	OECD	72.6	69.8
	EU	72.9	70.0
Solving an equation like 3x+5=17	Ireland	80.2	77.9
	OECD	84.8	78.4
	EU	85.5	78.4

Source: e-appendix A6.9

[10] Eight items made up the PISA 2012 self-efficacy in mathematics index in total.

6.3.2 Self-efficacy related to mathematical reasoning and 21st century mathematics

Student self-efficacy in performing tasks that require mathematical reasoning and 21st century mathematics skills was a measure that was introduced to PISA for the first time in 2022. This included tasks such as representing data visually and extracting data from visualisations, as well as mathematics in real-world contexts and computer-related tasks. Students rated their level of confidence in completing each task from four options ranging from not at all confident to very confident.

Across six of the ten tasks, students in Ireland reported higher levels of confidence than their peers across both OECD and EU countries, on average (Table 6.9). There were particularly high levels of confidence among students in Ireland about extracting mathematical information from diagrams, graphs, or simulations (76.8%); noticeably higher than the corresponding percentages at the OECD (64.5%) and EU (65.7%) averages. Students in Ireland also displayed relatively high confidence in evaluating the significance of observed patterns in data, with over 60% of students reporting they were confident or very confident in doing this compared to about 50% of students across both OECD and EU countries, on average. Similarly, students in Ireland were more confident in representing a situation mathematically than their OECD and EU counterparts, with 64.9% of students in Ireland reporting confidence in this area compared to about 55% across OECD and EU countries, on average.

Table 6.9 - Percentages of students reporting levels of confidence about a range of mathematical reasoning and 21st century mathematics tasks, in Ireland and at the OECD and EU averages

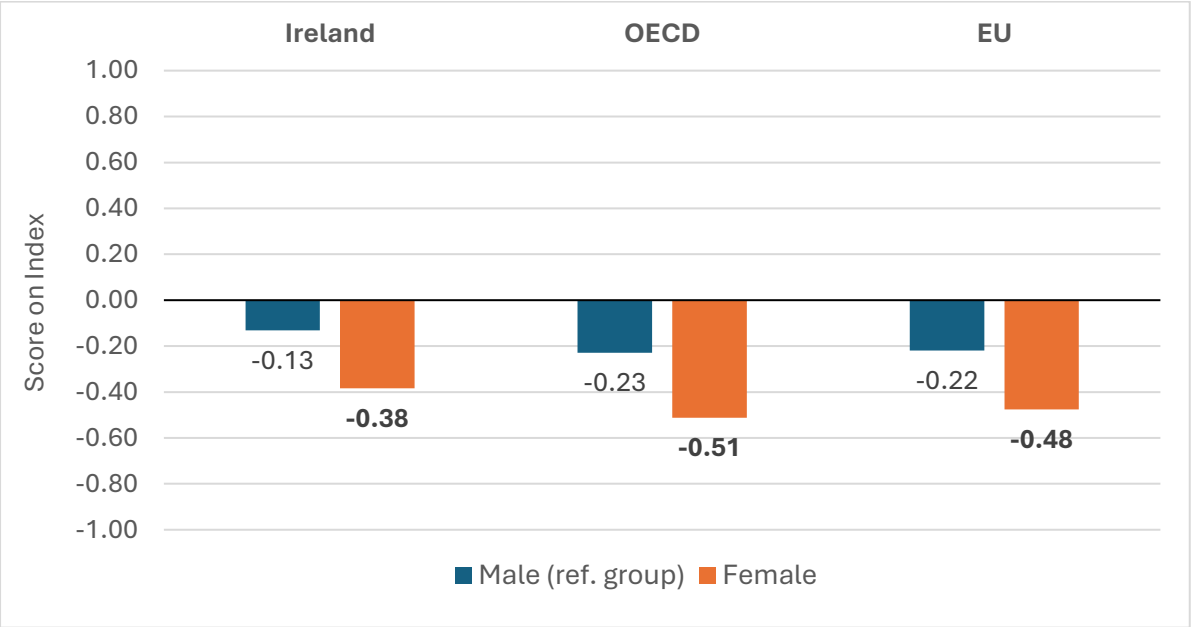
		Not at all confident/Not very confident	Confident/Very confident
		%	%
Extracting mathematical information from diagrams, graphs, or simulations	Ireland	23.2	76.8
	OECD	35.5	64.5
	EU	34.3	65.7
Interpreting mathematical solutions in the context of a real-life challenge	Ireland	45.6	54.4
	OECD	47.5	52.5
	EU	48.1	51.9
Using the concept of statistical variation to make a decision	Ireland	52.2	47.8
	OECD	58.5	41.5
	EU	59.9	40.1
Identifying mathematical aspects of a real-world problem	Ireland	43.9	56.1
	OECD	48.8	51.2
	EU	50.3	49.7
Identifying constraints and assumptions behind mathematical modelling	Ireland	67.0	33.0
	OECD	59.7	40.3
	EU	60.2	39.8
Representing a situation mathematically using variables, symbols, or diagrams	Ireland	35.1	64.9
	OECD	44.3	55.7
	EU	45.4	54.6
Evaluating the significance of observed patterns in data	Ireland	39.6	60.4
	OECD	48.7	51.3
	EU	50.8	49.2
Coding/programming computers	Ireland	72.8	27.2
	OECD	66.5	33.5
	EU	65.5	34.5
Working with computer mathematics systems (e.g. spreadsheets, programming software, graphing calculators)	Ireland	55.8	44.2
	OECD	48.1	51.9
	EU	46.7	53.3
Calculating the properties of an irregularly shaped object	Ireland	49.8	50.2
	OECD	55.7	44.3
	EU	56.3	43.7

Source: e-appendix A6.10

Students in Ireland were less likely than their OECD and EU peers, on average, to report confidence in identifying constraints and assumptions behind mathematical modelling (IRL: 33.3%; OECD: 40.3%; EU: 39.8%), coding or programming computers (IRL: 27.2%; OECD: 33.5%; EU: 34.5%) or working with computer mathematics system such as spreadsheets (IRL: 44.2%; OECD: 51.9%; EU: 53.3%).

An index of self-efficacy in mathematical reasoning and 21st century skills was created by combining the data from the above responses. The index was scaled to have a mean of zero and a standard deviation of one across all OECD countries. Students in Ireland had a mean score of 0.08 on this index compared to averages of 0.01 across OECD countries and -0.01 across EU countries, pointing to slightly higher levels of confidence with these tasks among students in Ireland; these differences were statistically significant. There were significant differences between male and female students in Ireland on this index, with males having a significantly higher mean score on the self-efficacy in mathematical reasoning and 21st century skills than their female counterparts (Figure 6.3). The order and magnitude of gender differences at the OECD and EU averages was similar to Ireland, and these differences were also statistically significant.

Figure 6.3 – Mean scores on the index of self-efficacy in mathematical reasoning and 21st century skills, by gender, in Ireland and at the OECD and EU averages



Source: e-appendix A6.3. Significant differences from the reference group are highlighted in bold.

6.4. Summary

This chapter examined students' attitudes and self-beliefs related to mathematics, providing insights into how students in Ireland perceive mathematics in comparison to their peers across OECD and EU countries. This encompassed student attitudes towards mathematics relative to other core subjects, as well as the extent of their anxiety and self-efficacy related to mathematics.

While the vast majority of students in Ireland are motivated to succeed in mathematics, and at slightly higher levels than their OECD peers, only 4% are more motivated to do well in mathematics relative to other core subjects like English and science, which was slightly below the corresponding OECD and EU average percentages. Male students reported slightly higher, albeit still low, levels of relative motivation to do well in mathematics than female students, on average. This trend was also observed on average across OECD and EU countries.

Just over 40% of students in Ireland agreed that mathematics was easy for them, slightly lower than the corresponding proportions among students across the OECD and EU on average. Fewer than 8% of students in Ireland indicated that they perceived mathematics to be easier relative to other core subjects, which was lower than the perceived levels of relative ease internationally. Gender differences were also apparent among students in Ireland, as well as across OECD and EU countries on average, with males more likely than females to perceive mathematics as easy relative to other core subjects.

About 35% of students in Ireland reported that mathematics was one of their favourite subjects, slightly lower than the corresponding percentages at the OECD and EU averages. When it comes to their attitude to mathematics relative to English and science, just over 10% indicated a relative preference for mathematics over these core subjects, again slightly lower than their OECD and EU peers, on average. A small gender difference on this indicator was observed in Ireland, and at the OECD and EU averages, with male students indicating a relative preference for mathematics at a higher rate than female students.

Students in Ireland had a higher mean score on the PISA index of mathematics anxiety than students across OECD and EU countries, on average, indicating greater

levels of anxiety among students in Ireland. However, levels of anxiety among students in Ireland were comparatively lower than their international peers when it comes to feelings of nervousness and helplessness when actually doing mathematics tasks. Large differences were apparent when analysed by gender. Female students in Ireland indicated elevated levels of mathematics anxiety compared to male students, on average. Similarly, at the OECD and EU averages, female students tended to report higher levels of anxiety related to mathematics relative to their male peers, although the gender differences were narrower than in Ireland.

The chapter also explored students' self-efficacy, focusing on both formal and applied mathematics tasks, as well as challenges requiring mathematical reasoning and 21st-century skills. On average, students in Ireland expressed higher confidence in formal and applied tasks, as well as in mathematical reasoning and 21st-century skills, compared to their OECD and EU counterparts. However, notable and statistically significant gender differences emerged, with male students reporting greater confidence, on average, than female students in Ireland and internationally.

Foras Taighde ar Oideachas
Educational Research Centre

7. Summary and discussion

PISA examines student achievement across three domains: mathematics, reading, and science. This report described PISA mathematics performance in Ireland overall, as well as among higher and lower achieving students, and across the various content and cognitive areas covered by PISA. Comparisons were made internationally, by gender and over time. The report went on to analyse the mathematics classroom, exploring the organisation of student learning, disciplinary climate and the use of digital devices in mathematics lessons. Further to this, the teaching and learning of mathematics was considered, looking at teacher behaviours that encourage cognitive activation, creative pedagogies and mathematics teacher support, before examining students' learning strategies. The report also examined student engagement with and exposure to mathematics, before analysing their attitudes and self-beliefs related to mathematics.

7.1. Summary of key findings

7.1.1. Mathematics performance in Ireland

Students in Ireland achieved an overall mathematics mean score of 491.6, significantly higher than the OECD mean score of 472.4 in PISA 2022. Eight countries had similar scores and nine countries achieved significantly higher mean scores than Ireland. Ireland's overall mean achievement score declined significantly between 2018 (mean score of 499.6) and 2022, having been relatively stable across the three previous cycles. This reflected a similar trend across the OECD, although the decline in Ireland in 2022 was narrower than at the OECD average. Ireland's mean score was also significantly above the OECD average score in each cycle since 2012.

Male students achieved a higher mean score than female students in Ireland (497.8 compared to 485.1) in 2012, and the difference was statistically significant. This was also the case on average across OECD countries, but the difference was less pronounced. This gender gap in mathematics achievement has been evident across a number of cycles. However, in 2018, the gap reduced and was not statistically significant due to a significant decline in the performance of male students in that cycle.

PISA also describes student performance in terms of proficiency levels which outline the types of tasks students are expected to be able to complete at each level. The percentage of students performing below baseline proficiency in mathematics (i.e., below Proficiency Level 2) increased significantly from almost 16% to 19% between 2018 and 2022. The percentage of students performing at the highest levels in PISA mathematics (i.e., Levels 5 and 6) in Ireland decreased steadily from almost 11% in 2012 to just over 7% in 2022. The increase in the percentage of students below baseline proficiency in Ireland, and the decrease in students at the highest levels in Ireland between 2018 and 2022 is largely driven by a decrease in performance among female students. When compared to the OECD average in PISA 2022, a smaller percentage of students in Ireland performed below baseline proficiency, and the percentage performing at the highest levels of proficiency was also slightly smaller.

As mathematics was the major domain in PISA 2022, results also describe students' performance across different mathematical content areas and cognitive processes. The four mathematics content areas are: change and relationships, space and shape, quantity and uncertainty and data. On average, students in Ireland in 2022 performed best in the area of uncertainty and data, followed by quantity and then change and relationships, and considerably less well in the area of space and shape. This was also the case the last time mathematics was the major domain, in 2012. Average student performance declined across all content areas between 2012 and 2022, but less so in shape and space. Male students in Ireland performed, on average, significantly better in all four mathematical content areas compared to females, and the gap was biggest in the area of space and shape at 17.9 score points.

On three of the four mathematical content subscales, a higher percentage of students in Ireland performed below baseline proficiency in 2022 compared to 2012, with a greater increase in the proportion of male students performing below baseline proficiency compared to female students in these areas. In contrast, there was an overall decline of 1.2 percentage points since 2012 in the proportion of students performing below Level 2 in the space and shape content area. This was largely due to a lower proportion of female students performing below baseline proficiency, indicating an improvement among female students in this area since 2012.

Across all four content areas there was a reduction in the proportion of students performing at the highest levels of proficiency in 2022 when compared to 2012. These declines were slightly greater among female students, except in the area of space and shape.

PISA also examines student performance across four mathematics cognitive processes: formulating, employing, interpreting and reasoning. Students in Ireland, on average, performed best on the interpreting subscale, followed closely by the employing subscale. Average performance in the area of reasoning was somewhat lower, and lowest on the formulating subscale. On average, male students performed better than female students in Ireland in each of the cognitive processes.

Across the four cognitive processes, between 19% and 23% of students in Ireland performed below the baseline proficiency levels, with the interpreting subscale having the lowest percentage of students in Ireland performing below the baseline proficiency, and formulating having the highest percentage. Just over 10% of students in Ireland performed at the highest levels of proficiency on the employing subscale, with the proportions being slightly lower for the interpreting and formulating subscales. Almost 7% performed at the highest levels on the reasoning subscale. Gender differences across the four cognitive process subscales are larger among higher-achieving than lower-achieving students in Ireland. At the higher end of the performance distribution, gender differences favour male students, and the largest difference was on the formulating subscale, with almost 12% of male students and 6% of female students reaching this level. It should be noted that due to reclassification of some trend items, trend analysis between 2012 and 2022 is not presented for the cognitive processes.

7.1.2. The mathematics classroom

The student-mathematics teacher ratio was 78 in Ireland, meaning that for every 78 post-primary students there was one mathematics teacher. This compares favourably to a mean student-mathematics teacher ratio of 83 across OECD countries and 82 across EU countries. The mean mathematics class size in Ireland (24 students) was on a par with the EU average, and slightly below the OECD average of 25.

Substantially fewer students across both OECD (38.4%) and EU (37.5%) countries, on average, attended schools where there was at least one form of ability grouping in all classes, compared to 61.1% of students in Ireland.

Students in Ireland had a noticeably more positive perception of the disciplinary climate in their mathematics classroom, with a mean score of 0.18 on this index compared to 0.02 across OECD countries and -0.03 across EU countries, on average. This was particularly the case in relation to distractions relating to the use of digital resources. When broken down by gender, female students in Ireland and across both OECD and EU countries, on average, were more likely to report a better disciplinary climate in their mathematics classes than male students; these differences were statistically significant.

Fewer students in Ireland (31%) attended a school where the principal reported that the school had a policy on the use of digital devices in mathematics classes compared to the OECD (40%) and EU (41%) averages. However, student reports on the frequency of using digital resources in mathematics classes were similar in Ireland and across both OECD and EU countries, on average.

7.1.3. Teaching and learning mathematics

Students in Ireland reported high levels of teacher behaviours that foster reasoning, such as asking students to justify answers. The reports from students in Ireland exceeded the levels reported by students across the OECD and EU. Ireland's score on this index was 0.18, compared to the OECD average of 0.00 and the EU average of -0.01. Student reports of teacher behaviours that encourage mathematical thinking were comparable with the OECD and EU averages. However, gender gaps in favour of male students in perceptions of higher exposure to these teaching behaviours were more pronounced in Ireland than across the OECD and EU on average.

Creativity is fostered and supported to a moderate extent in Ireland (index score of 0.05), slightly above the OECD average (0.00) and higher than the EU average (-0.08), based on student reports. There were no significant gender differences in Ireland, while there were significant differences in favour of male students across the OECD and EU.

Students in Ireland reported higher levels of teacher support (index score of 0.07) compared to their OECD and EU peers (-0.03 and -0.17, respectively), with gender differences in favour of male students in Ireland and internationally. They also reported strong self-regulation and proactive study behaviours, with higher frequencies among students in Ireland than their OECD and EU peers. Females in Ireland consistently outperformed males in these proactive behaviours, a trend also observed across the OECD and the EU.

7.1.4. Students' interaction with mathematics

The proportion of students in Ireland attending schools that offered additional mathematics lessons was on a par with the OECD average, and slightly below the average across the EU. Over 90% of those were in schools that offered additional mathematics lessons for learning support across Ireland, the OECD, and the EU. More students in Ireland (68.5%) attended schools that also offered additional mathematics lessons for enrichment compared to the OECD and EU averages (60.3% and 57.5% respectively). However, noticeably more students in Ireland (67.7%) reported that they did not participate in additional mathematics lessons than across the OECD (49.8%) and the EU (49.7%).

While the data in relation to student reports of their familiarity with specific mathematics concepts presents a mixed picture, overall, students in Ireland had slightly higher levels of familiarity with the mathematics concepts presented (index score of 0.58) compared to their OECD and EU peers (0.52 and 0.47, respectively). Male students reported slightly higher levels of familiarity across Ireland, the OECD and the EU.

Students in Ireland reported somewhat higher levels of exposure to formal and applied mathematics tasks (index score of 0.22) compared with their peers in the OECD and EU (0.01 and 0.05, respectively). Females reported having encountered these tasks at higher levels than males; while the difference was higher in Ireland than internationally, it was not statistically significant.

Students in Ireland had higher levels of exposure to mathematical reasoning and 21st century mathematics tasks overall (index score of 0.19) than their OECD and

EU counterparts (0.01 and -0.03, respectively). While the gender gap favoured female students in Ireland, the opposite was true across the OECD and the EU.

7.1.5. Students' attitudes and self-beliefs related to mathematics

Most students in Ireland (94.3%) are motivated to succeed in mathematics. However, only a very small proportion (3.6%) are more motivated to do well in mathematics than in other core subjects like English and science, with a slight gender gap in favour of male students. This picture is similar to the averages across OECD and EU countries.

Just over 40% of students in Ireland agreed that mathematics was easy for them, and fewer than 8% of students in Ireland indicated that they perceived mathematics to be easier than other core subjects. Both figures were slightly lower than the corresponding percentages across the OECD and EU on average. Male students were more likely to perceive mathematics as easy relative to other core subjects in Ireland, and across the OECD and EU on average.

The proportions of students in Ireland who reported that mathematics was one of their favourite subjects (35.8%), and who reported a relative preference for mathematics (10.4%) over English and science, were slightly lower than across the OECD and EU on average. Male students indicated a relative preference for mathematics at a higher rate than female students in Ireland, and at the OECD and EU level.

Students in Ireland had a higher mean score on the PISA index of mathematics anxiety (0.21) than students across the OECD and EU, on average (0.17 and 0.12 respectively). Female students in Ireland indicated elevated levels of mathematics anxiety (0.50) when compared with male students (-0.08). This pattern is also reflected, albeit to a slightly lesser extent, among students internationally.

Students in Ireland largely reported higher confidence in formal and applied tasks (index score of -0.26) in comparison to their OECD and EU peers (-0.37 and -0.35 respectively). Notable and statistically significant gender differences in favour of male students were apparent in Ireland and internationally. While students in Ireland

reported slightly higher levels of self-efficacy in relation to mathematical reasoning and 21st century tasks overall (index score of 0.08) compared to their OECD and EU peers on average (0.01 and -0.01 respectively), levels of self-efficacy were relatively low for items relating to computer-based mathematical tasks. Once again, noticeable gender differences were apparent in Ireland and internationally, with male students indicating greater levels of self-efficacy.

7.2. Discussion

7.2.1. Strengths of post-primary mathematics education in Ireland

One theme that emerges from the PISA 2022 data is that there are several positive findings of note related to mathematics teaching and learning in Ireland, when compared to the OECD and EU averages. For example, although students' mean mathematics achievement declined significantly between 2018 and 2022 in Ireland, the decline was lower than the corresponding decline across OECD countries as a whole, and performance in Ireland remains significantly above the OECD average. In general, data from large-scale assessments that were collected prior to and following the COVID-19 pandemic show that many countries experienced large declines in performance during this period while relatively small changes in student achievement were observed in Ireland (Jakubowski et al., 2024; McHugh et al., 2024a).

Students in Ireland were more likely to report teacher behaviours that foster reasoning skills – such as asking students to justify answers and encouraging them to persevere with challenging mathematics tasks – and to report that creativity was fostered and supported in class. In addition, the student-mathematics teacher ratio is slightly more favourable in Ireland than internationally, while 15-year-old students report a more positive perception of the disciplinary climate in classrooms in Ireland. Students also contribute to this environment with their own efforts, as reflected in their reports of self-regulation and proactive study behaviours (such as paying attention in class and persisting with assignments). Students in Ireland reported higher levels of these constructive behaviours than their OECD and EU peers.

Students' positive reports about the extent to which original ideas were encouraged, time was given to develop creative solutions, and guidance and encouragement was received from teachers, paint a picture of a teaching and learning environment where students are often encouraged and supported to achieve their potential. A point of comparison can be drawn between these student reports of post-primary mathematics teacher behaviours in PISA and the self-reported practices of Second Year mathematics teachers in TIMSS 2023. Findings from TIMSS show that the frequency with which mathematics teachers report asking their students to listen to them explaining how to solve problems, or to listen to them explaining new content, has increased over the last decade and is now very common (Pitsia et al., 2025). However, consistent with the student reports in PISA 2022, teachers do also report regularly asking students to apply what they have learned to new problem situations on their own (i.e., develop solutions to problems), to practise procedures on their own, and to explain their answers in class (Pitsia et al., 2025). The positive interactions reported by student respondents in PISA 2022 may also, in part, be reflective of practices in Transition Year mathematics lessons in particular, given that Transition Year students constituted a majority of the PISA 2022 sample (as reported in Chapter 1). Analysis of teacher data from PISA 2022 shows that mathematics teachers report almost universal agreement that the aims of mathematics classes in Transition Year include improving students' confidence in mathematics, and deepening their mathematics skills and understanding (Karakolidis et al., 2025).

Overall, students in Ireland reported a slightly higher level of familiarity with the range of mathematical concepts presented to them in the PISA questionnaire than students on average across the OECD and the EU. Similarly, students in Ireland generally reported higher levels of exposure to formal and applied mathematics tasks, and to mathematical reasoning and 21st century mathematics tasks, when compared to their peers across the OECD and the EU. Tasks that students in Ireland were notably more familiar with included calculating the tax on an item, and extracting mathematical information from diagrams and graphs. These findings seem to be indicative of higher levels of exposure to a broad range of concepts and tasks in the mathematics classroom.

However, although students in Ireland were comparatively more familiar with some mathematical concepts (most notably *probability*), they were comparatively less

familiar with others (particularly *divisor* and *congruent figures*). This is consistent with a previous analysis of relative strengths and weaknesses in mathematics among Second Year students (McHugh et al., 2024b), which demonstrated examples of relative weakness in geometry including topics related to geometric transformations and congruent and similar shapes, and a particularly strong performance in topics related to probability. Findings such as these point to some areas for further improvement in the teaching and learning of mathematics in Ireland, discussed further below.

7.2.2. Student attitudes to mathematics

One area that is clearly less positive for students in Ireland is their higher levels of mathematics anxiety, when compared with their peers across the OECD and EU on average. However, some nuances can be noted in this finding which can inform efforts to support students in their mathematics learning. It was notable that levels of agreement among students in Ireland were comparatively lower than their international peers for items in the anxiety index regarding feelings of nervousness and helplessness when engaged in mathematics tasks, and were comparatively higher on those related to poor grades and failing. This suggests that while students in Ireland may be relatively comfortable actually doing mathematics tasks, there is a high degree of anxiety related to test results.

A worrying aspect of these findings is that students' attitudes towards mathematics appear to be getting worse over time. The current data show that students' levels of anxiety related to mathematics increased between 2012 and 2022, both in Ireland and across OECD countries on average. Similarly, students in 2022 (in Ireland and at the OECD average) reported lower self-efficacy related to formal and applied mathematics compared to their counterparts in 2012.

Analysis of TIMSS data has shown that Second Year students' liking of mathematics and the extent to which they value mathematics has also deteriorated in recent years (Denner et al., 2025), supporting these findings from PISA and indicating a broader decline in attitudes. (An exception can be seen in students' levels of confidence in mathematics, which have remained mostly stable since 2015; Denner et al., 2025.) Nonetheless, it is clear that large proportions of post-primary students now explicitly

express strongly negative views towards the subject. For example, more than half of Second Year students report not liking mathematics and not being confident in it, while almost one-third of students do not value mathematics (Denner et al., 2025).

The extent of these negative attitudes – coupled with their downward trends across a range of relevant indicators – suggest that renewed efforts are needed to achieve the aspirations set out at a policy level for students to develop positive attitudes and have positive experiences of learning in mathematics and other STEM-related subjects (DES, 2015, 2017b; Department of Education, 2024). Further cause for concern can be found in the gendered patterns of attitudes towards mathematics that are found in both primary (Denner et al., 2025) and post-primary schools, as discussed next.

7.2.3. Gender differences in favour of male students

7.2.3.1. Gender differences in mathematics achievement

The overall gap in achievement between male and female students widened between 2018 and 2022, and was statistically significant. A particular point of note is that the widening gap was largely driven by a decrease in performance among female students. This finding is consistent with recent data from TIMSS, where the mean mathematics performance of female students in Second Year declined significantly between 2019 and 2023 (McHugh et al., 2024a).

Similarly, the decline in the percentage of students in Ireland at the highest levels of mathematics proficiency in PISA 2022 (about 7%, compared to 8% in the previous cycle) is largely attributable to a decline in the proportion of female students reaching this high level of proficiency. This has also contributed to a widening gender gap among the higher-achieving students in Ireland in PISA 2022, with about twice as many boys as girls reaching the higher proficiency levels. TIMSS data from Second Year students show some similarity, with a significantly higher percentage of boys than girls reaching the highest benchmark of achievement in 2023 (McHugh et al., 2024a), albeit that the relative difference between genders on this measure is smaller in TIMSS than in PISA.

In terms of the mathematical content areas, the gender gap in performance narrowed slightly in Ireland in 2022 relative to 2012, which was the last cycle in which scores for mathematical content areas were available. Nonetheless, male students in Ireland performed significantly better in each content area compared to female students. Male students also performed better than female students in Ireland in each of the cognitive processes, both overall and at the highest and lowest proficiency levels.

A more positive finding was the stability of female students' performance in the space and shape domain, marking an exception to the broader pattern of declines in other content areas (and a decline among males in space and shape), as well as a reduction in the proportion of female students performing below baseline proficiency in space and shape (with stability among males on this indicator). The relatively encouraging performance of female students on space and shape in this cycle of PISA is noteworthy given that this content area (and corresponding areas such as geometry and measurement) has traditionally been relatively difficult for students in Ireland, and for female students in particular (e.g., McHugh et al., 2024a, 2024b).

7.2.3.2. Gender differences in attitudes to mathematics

Gender differences in favour of male students in PISA 2022 extend beyond achievement. In terms of teaching, male students in Ireland reported higher levels of teaching behaviours that fostered reasoning and encouraged mathematical thinking than female students, with the gender gap being larger in Ireland than across the OECD and EU on average. Additionally, male students reported higher levels of perceived teacher support than female students, both in Ireland and internationally.

While the gender gap in favour of males in relative motivation to do well in mathematics was small, male students were more likely to perceive mathematics as easy relative to other core subjects, and also to indicate a relative preference for mathematics at a slightly higher rate than female students. Noticeable gender differences were also apparent in confidence towards mathematics: male students reported significantly higher self-efficacy both in formal and applied tasks, and in relation to mathematical reasoning and 21st century tasks.

One of the most notable gender differences is in relation to mathematics anxiety. Overall, moderate levels of mathematics anxiety were apparent among all students in Ireland, and at slightly higher levels than across the OECD and EU. However, female students in Ireland indicated substantially elevated levels of mathematics anxiety when compared with male students. This pattern was also observed, to a lesser extent, internationally.

In contrast to other attitudinal indicators, female students reported a better disciplinary climate in their mathematics classes than males, both in Ireland and across the OECD. Similarly, reports of self-regulation and proactive study behaviours were higher among female students than male students (in Ireland and internationally), while female students in Ireland also reported higher levels of exposure both to formal and applied mathematics tasks and to mathematical reasoning and 21st century mathematics tasks. Finally, there were no significant gender differences in Ireland relating to perceived teacher support for creativity.

While these findings are based on students' reports, and are not a direct assessment of teaching practice, the lower levels of perceived support and encouragement in class reported by female students warrant further investigation. Similar differences have been reported in TIMSS, with female students reporting a lower liking of learning mathematics and lower confidence in mathematics than males (although male and female students reported valuing mathematics to a similar degree) (Denner et al., 2025). An improvement in this area could be an important step towards reducing gender gaps in mathematics achievement, as well as improving students' (perceptions of their) experiences at school more holistically.

Teacher preparation and teaching practices may be a contributory factor to the differences reported in students' experiences. Previous findings show that the proportion of Second Year students who are taught mathematics by a teacher whose main area of study included both mathematics and mathematics education has increased substantially in recent years (Pitsia et al., 2025), and teacher-reported data from PISA 2022 show that more than half of post-primary mathematics teachers had completed a bachelor's degree with mathematics and two-fifths had completed a higher diploma or postgraduate diploma with mathematics (Karakolidis et al., 2025). However, teachers with backgrounds in mathematics and/or mathematics education

are not necessarily evenly distributed, and practices may differ across school types. Pitsia et al. (2025) reported that students in boys' schools and mixed-gender schools are relatively more likely than those in girls' schools to be taught mathematics by a teacher whose main qualifications included both mathematics and mathematics education. Some differences in mathematics classroom practices were also reported by school gender type – for example, students in girls' schools and mixed-gender schools were more likely to be asked to memorise rules, procedures, and facts on a regular basis than their peers in boys' schools, while those in boys' schools were more likely to have their teacher explain new mathematics content to them in every or almost every lesson (Pitsia et al., 2025).

Future research could usefully examine the ways in which initial teacher education and teacher professional learning inform teaching practices which could, in turn, play a role in shaping students' attitudes to learning and to mathematics in particular. More broadly, looking outside the classroom, achieving a major improvement in girls' experiences of mathematics and the development of their attitudes to mathematics requires consideration of the ways in which girls are exposed to and engage with mathematics at home and in wider society. Addressing gender gaps in students' attitudes towards mathematics and numeracy through this broader lens – as well as the promotion of more positive attitudes to numeracy among both male and female students – is among the key aims of the current *Literacy, Numeracy and Digital Literacy Strategy (2024--2033)* (Department of Education, 2024).

7.2.4. Technology in mathematics lessons

The picture that emerged in relation to use of technology and digital resources in the mathematics classroom in Ireland was mixed.

Students' perception of the disciplinary climate in the mathematics classroom was more positive in Ireland than among their peers across the OECD and EU. The largest gaps were found in relation to distractions arising from using digital resources themselves or distractions caused by other students using digital resources in mathematics classes. More than half of students in Ireland reported that such distractions *never* occurred in mathematics lessons, which was substantially higher than the corresponding proportion across the OECD and the EU on average. This is

a reassuring finding in light of concerns about potential negative impacts of technology and digital devices in schools.

Other recent studies in Irish post-primary schools provide a broadly similar picture – for example, about one-third of digital team leaders endorsed the view that student distraction from digital resources is an impediment to learning (Donohue et al., 2024b), while the teachers of about one-fifth of Second Year students described keeping students 'on task' when they are using digital devices in mathematics classes as a major obstacle to their use of devices in lessons (albeit that this was also seen as being a partial obstacle for about half of students) (Pitsia et al., 2025). Taking the student perspectives from PISA 2022 and the teacher-provided perspectives from earlier studies on the whole, then, it appears that distraction related to digital devices can be a challenge but not necessarily an overwhelming one in many post-primary schools.

Fewer students in Ireland attended a school where the principal reported that the school had a policy on the use of digital devices in mathematics classes, compared to the average across OECD and EU countries. However, student reports on the frequency of using digital resources in mathematics classes in Ireland were on a par with the OECD and EU averages, with around a quarter of students reporting using digital devices in more than half of mathematics classes and just over one tenth using them in about half of lessons.

Finally, while students in Ireland reported slightly higher levels of self-efficacy overall in relation to mathematical reasoning and 21st century tasks compared to students across the OECD and EU on average, levels of self-efficacy were lower when it came to specifically computer-based mathematical tasks, such as coding/ programming computers and working with computer mathematics systems. Similarly, while students in Ireland reported higher levels of exposure to mathematical reasoning and 21st century tasks than their international peers, their reports of exposure to the computer-based mathematical tasks noted above were also comparatively lower.

Overall, these findings paint a picture of comparable access to digital resources and fewer disciplinary issues related to digital resources in Ireland, but with scope to

improve students' exposure to, and confidence in, computer-based mathematics tasks.

7.3. Looking towards PISA 2025

Results from the 2025 cycle of PISA will be published on 8th September 2026 and will provide an opportunity to assess how overall mathematics performance has changed since 2022. As science is the main focus of PISA 2025, further contextual information on mathematics is not included as part of this cycle. Ireland is, however, taking part in the 2027 cycle of TIMSS. As well as assessing mathematics performance for students in Fourth Class and Second Year, TIMSS also collects information on students' attitudes and engagement with mathematics, as well as some aspects of the teaching and learning of mathematics. The results of TIMSS 2027 will be published in late-2028.

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Appendices

Appendix A

PISA National Advisory Committee

Orlaith O'Connor (Department of Education and Youth, Chair, to July 2023)

Linda Ramsbottom, (Department of Education and Youth, Chair, from July 2023)

Liz O'Neill (Department of Education and Youth)

Elizabeth Smith (Department of Education and Youth)

Evelyn O'Connor (Department of Education and Youth to 2024)

Mark Bohan (Department of Education and Youth from 2024)

Paul Behan (National Council for Curriculum and Assessment)

Rachel Linney (National Council for Curriculum and Assessment)

Gerry Hyde (State Examinations Commission)

Brian Murphy (University College Cork)

Conor Galvin (University College Dublin)

Odilla Finlayson (Dublin City University)

Ronan Flatley (Mary Immaculate College)

Ryan Gallagher (University College Cork)

Brendan McMahon (University of Galway to 2022)

Tom McCloughlin (Dublin City University to 2022)

Philip Matthews (Trinity College Dublin to 2021)

Rachel Perkins (ERC, PISA Governing Board Member, to July 2025)

Brenda Donohue (ERC, PISA 2022 National Project Manager)

Theresa Walsh (ERC)

Conall Ó Duibhir (ERC)

Anastasios Karakolidis (ERC, PISA Governing Board Member, from July 2025)

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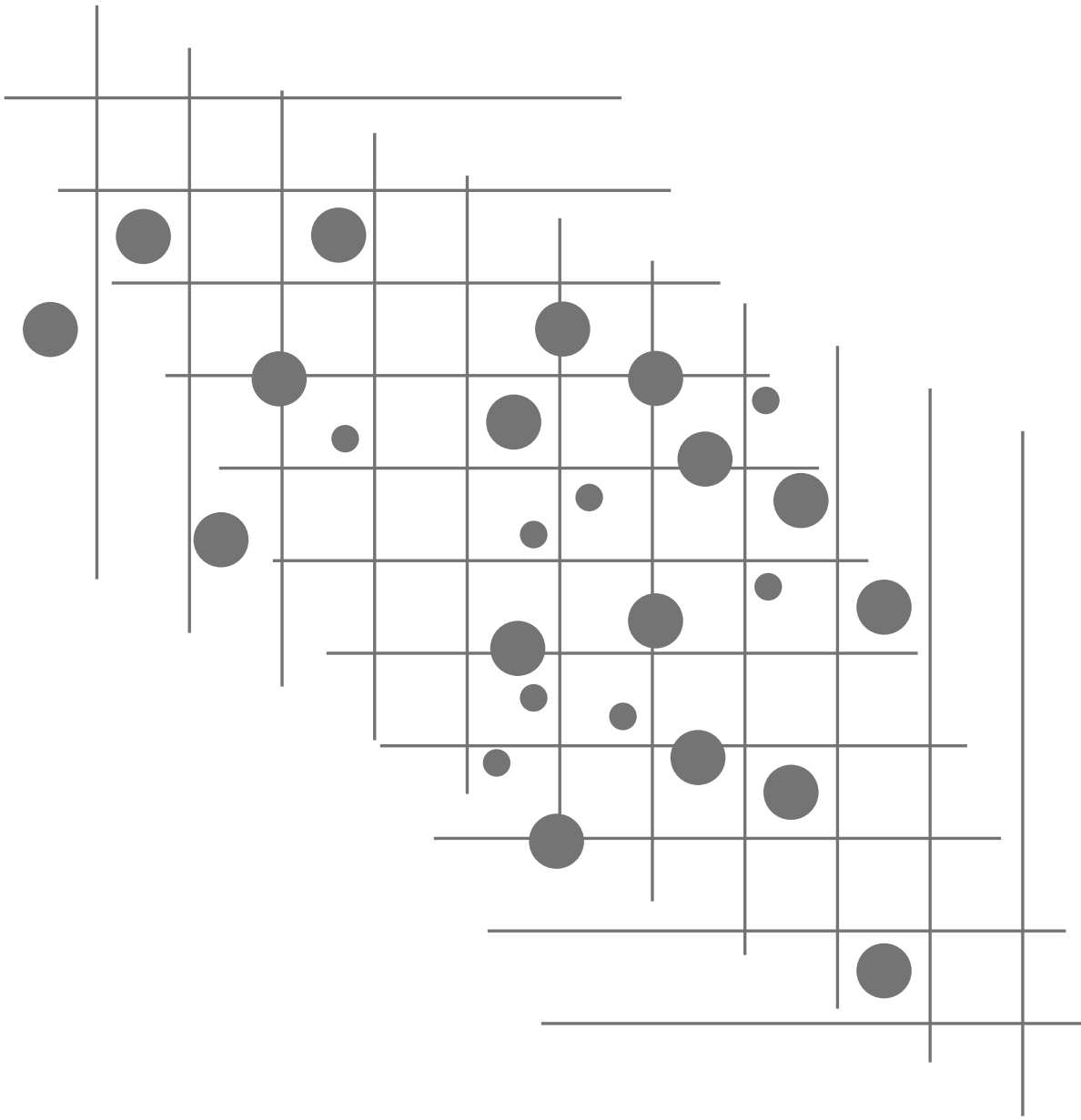

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