Annex A1. The construction of reporting scales and of indices from the student context questionnaire

The construction of reporting scales

The results of the PISA 2022 test are reported in a numerical scale consisting of PISA score points. This section summarises the test-development and scaling procedures used to ensure that PISA score points are comparable across countries and with the results of previous PISA assessments.

Assessment framework and test development

The first step in defining a reporting scale in PISA is developing a framework for each domain assessed. This framework provides a definition of what it means to be proficient in the domain; delimits and organises the domain according to different dimensions; and suggests the kind of test items and tasks that can be used to measure what students can do in the domain within the constraints of the PISA design (OECD, 2023[1]). These frameworks were developed by a group of international experts for each domain and agreed upon by the participating countries.

The second step is the development of the test questions (i.e. items) to assess proficiency in each domain. A consortium of testing organisations under contract to the OECD on behalf of participating governments develops new items and selects items from previous PISA tests (i.e. "trend items") of the same domain. The expert group that developed the framework reviews these proposed items to confirm that they meet the requirements and specifications of the framework.

The third step is a qualitative review of the testing instruments by all participating countries and economies to ensure the items' overall quality and appropriateness in their own national context. These ratings are considered when selecting the final pool of items for the assessment. Selected items are then translated and adapted to create national versions of the testing instruments. These national versions are verified by the PISA consortium.

The verified national versions of the items are then presented to a sample of 15-year-old students in all participating countries and economies as part of a field trial. This is to ensure that they meet stringent quantitative standards of technical quality and international comparability. In particular, the field trial serves to verify the psychometric equivalence of items across countries and economies (see Annex A6).

After the field trial, material is considered for rejection, revision or retention in the pool of potential items. The international expert group for each domain then formulates recommendations as to which items should be included in the main assessments. The final set of selected items is also subject to review by all countries and economies. This selection is balanced across the various dimensions specified in the framework and spans various levels of difficulty so that the entire pool of items measures performance across all component skills and a broad range of contexts and student abilities.

Proficiency scales for mathematics, reading, and science

Proficiency scores in mathematics, reading, and science are based on student responses to items that represent the assessment framework for each domain (see section above). While different students saw different questions, the test design, which ensured a significant overlap of items across different forms, made it possible to construct proficiency scales that are common to all students for each domain. In general, the PISA frameworks assume that a single continuous scale can be used to report overall proficiency in a domain but this assumption is further verified during scaling (see section below).

PISA proficiency scales are constructed using item-response-theory models in which the likelihood that the test-taker responds correctly to any question is a function of the question's characteristics and of the test-taker's position on the scale. In other words, the test-taker's proficiency is associated with a particular point on the scale that indicates the likelihood that he or she responds correctly to any question. Higher values on the scale indicate greater proficiency, which is equivalent to a greater likelihood of responding correctly to any question. A description of the modelling technique used to construct proficiency scales can be found in the *PISA 2022 Technical Report* (OECD, Forthcoming[2])

In the item-response-theory models used in PISA, the test items characteristics are summarised by two parameters that represent task difficulty and task discrimination. The first parameter, task difficulty, is the point on the scale where there is at least a 50% probability of a correct response by students who score at or above that point; higher values correspond to more difficult items. For the purpose of describing proficiency levels that represent mastery, PISA often reports the difficulty of a task as the point on the scale where there is at least a 62% probability of a correct response by students who score at or above that point.

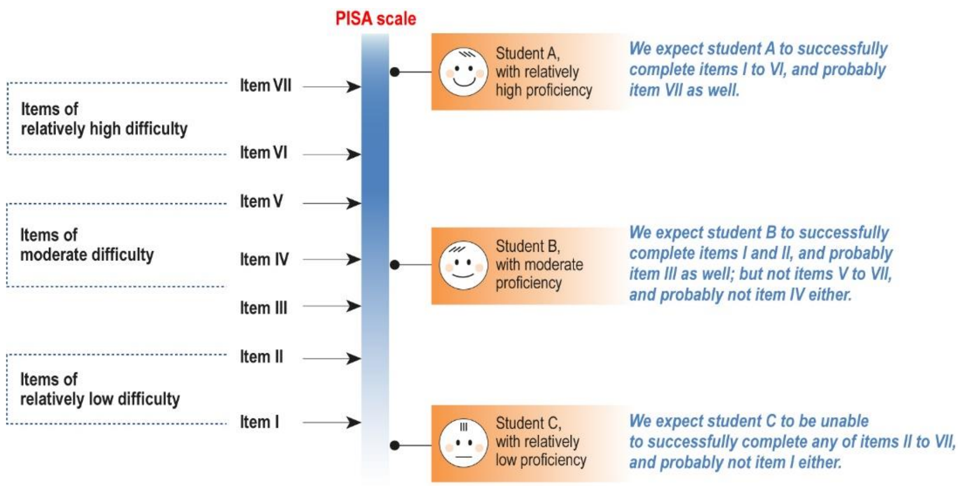
The second parameter, task discrimination, represents the rate at which the proportion of correct responses increases as a function of student proficiency. For an idealised highly discriminating item, close to 0% of students respond correctly if their proficiency is below the item difficulty and close to 100% of students respond correctly as soon as their proficiency is above the item difficulty. In contrast, for weakly discriminating items, the probability of a correct response still increases as a function of student proficiency, but only gradually.

A single continuous scale can therefore show both the difficulty of questions and the proficiency of test-takers (see Figure I.A1.1). By showing the difficulty of each question on this scale, it is possible to locate the level of proficiency in the domain that the question demands. By showing the proficiency of test-takers on the same scale, it is possible to describe each test-taker's level of skill or literacy by the type of tasks that he or she can perform correctly most of the time.

Estimates of student proficiency are based on the kinds of tasks students are expected to perform successfully. This means that students are likely to be able to successfully answer questions located at or below the level of difficulty associated with their own position on the scale. Conversely, they are unlikely to be able to successfully answer questions above the level of difficulty associated with their position on the scale.[1]

The higher a student's proficiency level is located above a given test question, the more likely he or she can answer the question successfully. The discrimination parameter for this particular test question indicates how quickly the likelihood of a correct response increases. The further the student's proficiency is located below a given question, the less likely he or she is able to answer the question successfully. In this case, the discrimination parameter indicates how fast this likelihood decreases as the distance between the student's proficiency and the question's difficulty increases.

Figure I.A1.1. Relationship between questions and student performance on a scale



How reporting scales are set and linked across multiple assessments

The reporting scale for each domain was originally established when the domain was the major focus of assessment in PISA for the first time: PISA 2000 for reading, PISA 2003 for mathematics and PISA 2006 for science.

The item-response-theory models used in PISA describe the relationship between student proficiency, item difficulty and item discrimination, but do not set a measurement unit for any of these parameters. In PISA, this measurement unit was chosen the first time a reporting scale was established. The score of "500" on the scale was defined as the average proficiency of students across OECD countries; "100 score points" was defined as the standard deviation (a measure of the variability) of proficiency across OECD countries.[2]

To enable the measurement of trends, achievement data from successive assessments are reported on the same scale. It is possible to report results from different assessments on the same scale because in each assessment PISA retains a significant number of items from previous PISA assessments. These are known as trend items. All items used to assess reading and science in 2018 and a significant number of items used to assess mathematics (74 out of 234) were developed and already used in earlier assessments. Their difficulty and discrimination parameters were therefore already estimated in previous PISA assessments.

The answers to the trend questions from students in earlier PISA cycles, together with the answers from students in PISA 2022, were both considered when scaling PISA 2022 data to determine student proficiency, item difficulty and item discrimination. In particular, when scaling PISA 2022 data, item parameters for new items were freely estimated, but item parameters for trend items were initially fixed to their PISA 2018 values, which, in turn, were based on a concurrent calibration involving response data from multiple cycles. All constraints on trend item parameters were evaluated and, in some cases, released in order to better describe student-response patterns. See the *PISA 2022 Technical Report* (OECD, Forthcoming[2]) for details.

The extent to which the item characteristics estimated during the scaling of PISA 2018 data differ from those estimated in previous calibrations is summarised in the "link error", a quantity (expressed in score points) that reflects the uncertainty in comparing PISA results over time. A link error of zero indicates a perfect match in the parameters across calibrations, while a non-zero link error indicates that the relative difficulty of certain items or the ability of certain items to discriminate between high and low achievers has changed over time, introducing greater uncertainty in trend comparisons.

How many scales per domain? Assessing the dimensionality of PISA domains

PISA frameworks for mathematics, reading, and science assume that a single continuous scale can summarise performance in each domain for all countries. This assumption is incorporated in the item-response-theory model used in PISA. Violations of this assumption therefore result in model misfit, and can be assessed by inspecting fit indices.

After the field trial, initial estimates of model fit for each item, and for each country and language group, provide indications about the plausibility of the uni-dimensionality assumption and about the equivalence of scales across countries. These initial estimates are used to refine the item set used in each domain: problematic items are sometimes corrected (e.g. if a translation error is detected); and coding and scoring rules can be amended (e.g. to suppress a partial-credit score that affected coding reliability, or to combine responses to two or more items when the probability of a correct response to one question appears to depend on the correct answer to an earlier question). Items can also be deleted after the field trial. Deletions are carefully balanced so that the set of retained items continues to provide a good balance of all aspects of the framework. After the main study, the estimates of model fit are mainly used to refine the scaling model (some limited changes to the scoring rules and item deletions can also be considered).

Despite the evidence in favour of a uni-dimensional scale for the “major” domain (i.e. mathematics in PISA 2022), PISA nevertheless provides multiple estimates of performance, in addition to the overall scale, through so-called “subscales”. Subscales represent different framework dimensions and provide a more nuanced picture of performance in a domain. Subscales within a domain are usually highly correlated across students (thus supporting the assumption that a coherent overall scale can be formed by combining items across subscales). Despite this high correlation, interesting differences in performance across subscales can often be observed at aggregate levels (across countries, across education systems within countries, or between boys and girls).

Summary descriptions of the proficiency levels of mathematical subscales

Tables I.A1.1 to I.A1.8 (below) provide summary descriptions of proficiency levels on each mathematical subscale. In some mathematical subscales there were no test items in the PISA 2022 Mathematics assessment to describe skills at levels 1c or 1b.

PISA 2022 results on mathematics subscales are included in Annex B1 (for countries and economies) and Annex B2 (for regions within countries). Results on the percentage of students scoring at each proficiency level in mathematics subscales were estimated only for proficiency levels that had proficiency descriptors (i.e. test items measuring those levels).

Table I.A1.1. Proficiency levels on the mathematical process subscale: *Mathematical reasoning*

Level	What students can typically do
6	At Level 6, students use deductive and inductive reasoning to devise strategies to solve real-world problems that require inference and creativity to recognise the mathematical nature of the task. Tasks at this level are often presented abstractly and require reasoning to recognise how the context-specific language can be transformed into known mathematical concepts or procedures, which underlies making the mathematical context suitable for analysis. Students can solve problems that require visualising a nonstandard geometric model not explicitly shown or described in the task or that require a solid understanding of known algorithms. For example, they can transform given information to construct a visual model to represent a situation or they can use the definition of a procedure for computing a statistical measure to justify if a mathematical result is possible without having numerical values to manipulate. At this level, they use reasoning to critique the limits of a model, such as identifying if a model can or cannot be used in a particular situation, which is necessary for being able to interpret/evaluate the mathematical outcome in context. Students also use reasoning to construct mathematical arguments based on logic and contradictions, such as justifying if a conclusion can be made from a given data set or developing a counterexample in response to a claim.
5	At Level 5, students can recognise structure in problem situations that can be solved using an algorithmic approach. Students use computational thinking to design an optimal procedure, such as programming a sequence of commands, and then reflect on the solution to determine if it meets the given constraints. They can analyse situations and recognise how a known procedure or set of procedures can be applied as a way to justify, for example, if an object can fit into a particular space or if a plan for a geometric design is possible. At this level, they can determine how to develop an experiment and run simulations to collect data necessary for evaluating a context. Students can identify a counterexample or analyse a rule used in a pattern as a way to support a mathematical argument. Students also use reasoning to develop solution strategies by identifying which elements of a model vary and which are invariant.
4	At Level 4, students demonstrate reasoning ability by reflecting on solutions to explain mathematical concepts in real-world contexts. They can evaluate the reasonableness of a claim and provide mathematical justifications to either support or refute the claim, such as recognising how to apply a common procedure in a novel context or determining how to interpret data or information presented in articles, tables, or phone apps. At this level, students can use their understanding of arithmetic and algebraic properties to analyse how manipulating the variables in a model or the steps in a procedure will help explain the real-world results, or they can develop a model to derive a relationship between the variables used in an equation. Students can identify more complex geometric relationships from images of shapes or descriptions of their properties. They are able to reason inductively from sample results to inform decision making or reason about the likelihood of various outcomes related to a probability context.
3	At Level 3, students can apply reasoning by utilising definitions and making judgements necessary for transforming conceptual and contextual situations into mathematical problems. Students at this level can evaluate a claim based on devising simple strategies to connect the underlying mathematics with the context. They are able to solve problems that require making minimal assumptions, such as recognising the relative size of a region from a diagram or comparing graphs of population data. Students can reason about properties in a description of a geometric model to determine a simple algebraic relationship. At this level, they can also apply reasoning to solve problems involving familiar concepts presented in nonstandard ways, such as race results or statistical measures represented graphically on a coordinate plane.
2	At Level 2, students are able to use reasoning to infer relationships between conceptual and contextual elements in a problem or to devise a straightforward strategy for evaluating a claim. For example, they can order objects by recognising how the size of various objects relates to distance traveled or how to use given assumptions to compare two rate plans with varying prices. Students at this level can also use spatial reasoning, when provided with a model or diagram, to recognise an alternate representation of an image or to analyse simple geometric properties of the model.
1a	At Level 1a, students use reasoning to draw conclusions based on their understanding of simple mathematical concepts, such asevaluating the likelihood of an outcome in a familiar probability context.
1b	*There were no items in the PISA 2022 Mathematics assessment to describe this level on the scale.*
1c	*There were no items in the PISA 2022 Mathematics assessment to describe this level on the scale.*

Table I.A1.2. Proficiency levels for mathematical process subscale: *Formulating situations mathematically*

Level	What students can typically do
6	Students at Level 6 can typically apply a wide variety of mathematical content knowledge to transform and represent information from a broad variety of contexts into a mathematical form amenable to analysis. At this level, students can formulate and solve complex real-world problems involving significant modelling steps and extended calculations, such as applying their geometric knowledge to irregular shapes, inferring relevant parameters of a large data set, or analysing an experiment to recognise the mathematical relationship between objects. Students at Level 6 are able to identify the relationship between the key components of a problem and to develop algebraic formulations that accurately represent them.
5	At Level 5, students show an ability to use their understanding across a range of mathematical areas to transform information or data from a problem context into mathematical form, sometimes involving two or more variables. They are able to recognise a situation where statistical counting techniques can be applied or formulate inequalities based on given conditions. Students are able to manipulate relatively large data sets by determining appropriate mathematical operations to perform using a spreadsheet tool. They are able to analyse more complex geometric figures, for example, by recognising the relationship between the properties of a compound figure and the properties of individual shapes that comprise the compound figure. Students at this level can formulate a process to solve a problem where some of the information used is given as a range instead of a single value or when information is not given explicitly in the task.
4	At Level 4, students are able to solve complex problems in a variety of contexts that may require designing a sequence of steps to reach the solution. They also recognise when a single process, repeated iteratively, can lead to the solution. Students are able to run simulations to identify the underlying relationship between two or more variables. They can determine probabilities from data presented in two-way tables. Students at this level can also formulate linear algebraic expressions of relatively simple contexts involving one constraint, recognise an application of a known procedure from a data table and use that procedure to determine missing values, or formulate a method to compare information, such as the prices of several sale items. They can work with more complex geometric models of practical situations which contain all the relevant information needed for formulating the solution.
3	At Level 3, students can identify and extract information from a variety of sources, including text, geometric models, tables, and diagrams, where all necessary information is provided. They can identify basic mathematical concepts relevant for the model or identify how to transform information given in a diagram to data that can be input into a simulation. Students at this level are able to solve problems by recognising situations in which quantities are related proportionally or by performing a computation using a percentage in real-life contexts such as medical testing or ticket sales. They are able to solve simple multi-step problems where the sequence of steps needs to be determined, and each step requires translating some of the given information into a form that can be operated on mathematically.
2	At this level, students can understand clearly formulated instructions and information about simple processes and tasks in order to express them in a mathematical form. They can determine a rule used in a simple pattern, and then use that rule to extend the pattern to the next term. They are able to use information presented in tables or diagrams to identify or build a simple model of a practical situation. For example, they can revise a given formula to determine the number of seats in any row of a theatre. Students at this level are able to translate descriptions of situations to be operated on mathematically that first require identifying information relevant to the particular task. At this level, students begin to formulate situations involving non-integer quantities, provided all necessary information is given in the task.
1a	At this level, students can recognise an explicit model of a contextual situation from a list or translate a short verbal description so that it can be operated on using basic mathematical tools. Students at this level are able to work with simple models involving one operation and, at most, two variables. For example, they can select the appropriate model that represents the total number of items that can be produced based on a production rate. Students at this level are capable of formulating situations that involve whole numbers and where all relevant information is given.
1b	*There were no items in the PISA 2022 Mathematics assessment to describe this level on the scale.*
1c	*There were no items in the PISA 2022 Mathematics assessment to describe this level on the scale.*

Table I.A1.3. Proficiency levels for mathematical process subscale: *Employing mathematical concepts, facts and procedures*

Level	What students can typically do
6	Students at Level 6 are typically able to employ a strong repertoire of knowledge and procedural skills in a wide range of mathematical areas. They can solve problems involving several stages or a problem that does not have a well-defined solution method, such as computing the area of an irregularly shaped figure. They demonstrate an understanding of statistical data, and can apply that understanding, for example, to determine the probability of different events. Students at this level can observe regularities in information and use that to determine algorithms to apply to a situation. At Level 6, students' work is consistently precise and reflects a strong ability to work with different data formats and representations.
5	Students at Level 5 can employ a broader range of knowledge and skills to solve problems. They can sensibly link information in graphical and diagrammatic formats to textual information. Students can reason proportionally to find a unit rate or understand and apply the meaning of a concept to extract relevant information from a table to solve a problem. At this level, they can devise a strategy to extrapolate from a sample or to determine which of two savings options would be better in a situation involving variously priced items. Students demonstrate the ability to solve problems that require converting between units or working with constraints and can provide mathematical or conceptual arguments to support their results. They also demonstrate proficiency working with percentages and ratios.
4	At Level 4, students show an understanding of the context and can recognise efficient strategies for solving problems. For example, they can typically identify relevant data and information from contextual material and use it to perform such tasks as, calculating distances from a map, analysing a model based on percentages, or comparing the results from two different formulae to compute the same measure. They are able to determine how a rating system was used to support a claim or evaluate several construction designs to rank order them based on a given criterion. At this level, students can estimate values from a graph and use them to solve a problem or analyse statements relating quantities expressed in different numerical formats. They demonstrate an ability to work with ratios or problems that require a series of steps to be performed in a specific order.
3	Students at Level 3 demonstrate more flexibility in devising and implementing solution strategies for problems that can be solved in a variety of ways. They are able to solve problems where the information given in the task must first be analysed to determine which of a given set of processes should be implemented, such as determining a fine for exceeding a speed limit based on different driving speeds or a model for computing charges for water-usage. At this level, students are able to use the basic properties of angles to solve a geometric problem or are able to translate between graphical and tabular representations of the same data. Students show an ability to approximate a final solution from interim results or to recognise how a given constraint affects the conclusion. They can work with percentages, fractions, decimal numbers, proportional relationships, and simple non-linear contexts.
2	Students at Level 2 show an ability to work with given models in flexible ways, such as identifying the relevant information to input or manipulating information to make it amenable to use in the model (including models with multiple inputs or tasks that require using a calculator tool specific to the context). They are also able to determine the input when given the output. Students can apply familiar geometric concepts to analyse a spatial pattern. At this level, students show an understanding of place value in decimal numbers and can use that understanding to compare numbers presented in a familiar context. They can apply a known procedure that first requires understanding a data table to extract the necessary information. Students are able to solve simple problems using proportional reasoning and work with ratios.
1a	Students at Level 1a can solve well-defined problems that require minimal decisions. For example, they can make direct inferences from textual information that points to an obvious strategy to solve a given problem, particularly where the mathematical procedures are one- or two-step arithmetic operations with whole numbers or require application of a familiar procedure. Students are able to extract information presented in a variety of formats, such as advertisements, simple pie charts, diagrams, or tables, which contain all the needed information to solve a problem. At this level, students can compute simple percentages, recognise when quantities are related proportionally, find the total area of a standard region, or determine a cost saving.
1b	At Level 1b, students can employ straightforward, one-step procedures that are clearly defined in the task, and where all information is presented in simple tabular format. For example, they are able to determine the winner of a tournament, given the criterion for winning or locate information in a table based on a set of conditions.
1c	*There were no items in the PISA 2022 Mathematics assessment to describe this level on the scale.*

Table I.A1.4. Proficiency levels for mathematical process subscale: *Interpreting, applying and evaluating mathematical outcomes*

Level	What students can typically do
6	At Level 6, students are able to link multiple complex mathematical representations in an analytical way to identify and extract data and information that enables conceptual and contextual questions to be answered. Students at this level demonstrate creativity in order to evaluate claims or interpret solutions to problems that require greater insight to solve, such as using a simulation to determine a design that satisfies several conditions. They are able to interpret data sets with multiple variables that typically require having to perform two or more operations before being able to evaluate a set of given claims related to the data set. Students can recognise different possible subdivisions of an irregular shape based on interpreting a list of geometric properties of the irregular shape. At this level, students can readily interpret or evaluate percentages, frequency distributions, and statistical measures, such as means and medians, in a variety of contexts.
5	At Level 5, students demonstrate the ability to interpret complex situations that require analyses of the underlying mathematics and can apply their understanding of mathematical concepts to real-world situations to make judgements on the reasonableness of claims or results. For example, students can explain why a possible mathematical model does not fit the real-world context. They can interpret experimental results and devise a method for comparing and ranking the results based on a given criterion. At this level, students can evaluate statistical statements based on means or product ratings presented in multiple formats, or they can manipulate a data set so that the presentation facilitates interpretation of the provided information.
4	At Level 4, students are able to interpret and evaluate situations or outcomes that typically involve satisfying multiple conditions, in a range of real-world contexts. They are able to interpret simple statistical or probabilistic statements from data presented in tables or charts in such contexts as fitness levels or genetics. Students at this level are able to interpret experimental results to infer a relationship between two variables in order to evaluate a claim or explain how the computational result of an exper iment relates to a given set of specifications. They can determine if a solution is compatible with a particular context or recognise how different adjustments to an algorithm affect the results. At this level, students also are able to approach problems where their interpretation of the given information or model can influence the solution strategy they choose for the task.
3	Students at Level 3 show an ability to reflect on an outcome, or the process used to reach an outcome, in more complex contexts. For example, they can interpret an algebraic model of a design plan to determine what quantity a variable in the model represents or manipulate a set of data using a spreadsheet tool to analyse claims related to energy usage or changes in population data. Students are able to use simulation results to determine a relationship between two contextual variables or explain if a conjecture about a simple algorithm is true. Students demonstrate spatial reasoning by translating between two- and three-dimensional representations of solids or by understanding how properties of geometric figures are related. At this level, students can analyse relatively unfamiliar data presentations to support their conclusions or interpret solutions of non-integer values or ratios with respect to real-world contexts.
2	At Level 2, students can link conceptual and contextual elements of the problem to mathematics in order to solve problems in a variety of real-world contexts where the information is presented clearly. Students are able to evaluate outcomes, often without having to perform calculations, such as determining the angle measures of an object based on interpreting a description of its properties. They can interpret context-specific language into simple mathematical relationships, sometimes involving one or two constraints, or understand how relationships presented in graphical formats relate to the context, such as a graph of distance versus time. At this level, students can run simulations and interpret the results with respect to the conditions of the task involving one variable.
1a	At Level 1a, students are able to locate and utilise information in order to make sense of the context. They can interpret information that requires relating two simple data sources, such as tables. For example, they can relate information in one table showing how points are awarded to another table of match outcomes to solve a problem in a familiar context or to understand how data from one source is represented in another source. Students at this level can also recognise when some of the given information can be ignored with respect to the specific task.
1b	At Level 1b, students are able to interpret contextual information presented in one of a variety of formats, such as two-way tables or work schedules. They demonstrate an ability to process the information given basic constraints imposed by the task, such as determining which rule from a table to apply or when to plan an event.
1c	Students at Level 1c can interpret information from real-world contexts presented in simple diagrams or tables and then use that information to solve well-defined problems involving a single operation with whole numbers or straightforward comparisons.

Table I.A1.5. Proficiency levels on the mathematical content subscale: *Change and relationships*

Level	What students can typically do
6	At Level 6, students use significant insight, abstract reasoning and argumentation skills and technical knowledge and conventions to solve problems involving relationships among variables and to generalise mathematical solutions to complex real-world problems. They are able to create and use an algebraic model of a functional relationship incorporating multiple quantities. They apply deep geometrical insight to work with complex patterns. And they are typically able to use complex proportional reasoning, and complex calculations with percentage to explore quantitative relationships and change.
5	At Level 5, students solve problems by using algebraic and other formal mathematical models, including in scientific contexts. They are typically able to use complex and multi-step problem-solving skills, and to reflect on and communicate reasoning and arguments, for example in evaluating and using a formula to predct the quantitative effect of change in one variable on another. They are able to use complex proportional reasoning, for example to work with rates, and they are generally able to work competently with formulae and with expressions including inequalities.
4	Students at Level 4 are typically able to understand and work with multiple representations, including algebraic models of real-world situations. They can reason about simple functional relationships between variables, going beyond individual data points to identifying simple underlying patterns. They typically employ some flexibility in interpretation and reasoning about functional relationships (for example in exploring distance-time-speed relationships) and are able to modify a functional model or graph to fit a specified change to the situation; and they are able to communicate the resulting explanations and arguments.
3	At Level 3, students can typically solve problems that involve working with information from two related representations (text, graph, table, formulae), requiring some interpretation, and using reasoning in familiar contexts. They show some ability to communicate their arguments. Students at this level can typically make a straightforward modification to a given functional model to fit a new situation; and they use a range of calculation procedures to solve problems, including ordering data, time difference calculations, substitution of values into a formula, or linear interpolation.
2	Students at Level 2 are typically able to locate relevant information on a relationship from data provided in a table or graph and make direct comparisons, for example to match given graphs to a specified change process. They can reason about the basic meaning of simple relationships expressed in text or numeric form by linking text with a single representation of a relationship (graph, table, simple formula), and can correctly substitute numbers into simple formulae, sometimes expressed in words. At this level, student can use interpretation and reasoning skills in a straightforward context involving linked quantities.
1a	Students at Level 1a are typically able to evaluate single given statements about a relationship expressed clearly and directly in a formula, table, or graph. Their ability to reason about relationships, and change in those relationships, is limited to simple expressions and to those located in familiar situations, such as contexts involving unit rates. They may apply simple calculations needed to solve problems related to clearly expressed relationships.
1b	*There were no items in the PISA 2022 Mathematics assessment to describe this level on the scale.*
1c	*There were no items in the PISA 2022 Mathematics assessment to describe this level on the scale.*

Table I.A1.6. Proficiency levels on the mathematical content subscale: *Quantity*

Level	What students can typically do
6	At Level 6 and above, students conceptualise and work with models of complex quantitative processes and relationships; devise strategies for solving problems; formulate conclusions, arguments and precise explanations; interpret and understand complex information, and link multiple complex information sources; interpret graphical information and apply reasoning to identify, model and apply a numeric pattern. They are able to analyse and evaluate interpretive statements based on data provided; work with formal and symbolic expressions; plan and implement sequential calculations in complex and unfamiliar contexts, including working with large numbers, for example to perform a sequence of currency conversions, entering values correctly and rounding results. Students at this level work accurately with decimal fractions; they use advanced reasoning concerning proportions, geometric representations of quantities, combinatorics and integer number relationships; and they interpret and understand formal expressions of relationships among numbers, including in a scientific context.
5	At Level 5, students are able to formulate comparison models and compare outcomes to determine best price; interpret complex information about real-world situations (including graphs, drawings and complex tables, for example two graphs using different scales); they are able to generate data for two variables and evaluate propositions about the relationship between them. Students are able to communicate reasoning and argument; recognise the significance of numbers to draw inferences; provide a written argument evaluating a proposition based on data provided. They can make an estimation using daily life knowledge; calculate relative and/or absolute change; calculate an average; calculate relative and/or absolute difference, including percentage difference, given raw difference data; and they can convert units (for example calculations involving areas in different units).
4	At Level 4, students are typically able to interpret complex instructions and situations; relate text-based numerical information to a graphic representation; identify and use quantitative information from multiple sources; deduce system rules from unfamiliar representations; formulate a simple numeric model; set up comparison models; and explain their results. They are typically able to carry out accurate and more complex or repeated calculations, such as adding 13 given times in hour/minute format; carry out time calculations using given data on distance and speed of a journey; perform simple division of large multiples in context; carry out calculations involving a sequence of steps and accurately apply a given numeric algorithm involving a number of steps. Students at this level can perform calculations involving proportional reasoning, divisibility or percentages in simple models of complex situations.
3	At Level 3, students typically use basic problem-solving processes, including devising a simple strategy to test scenarios, understand and work with given constraints, use trial and error, and use simple reasoning in familiar contexts. At this level students typically can interpret a text description of a sequential calculation process, and correctly implement the process; identify and extract data presented directly in textual explanations of unfamiliar data; interpret text and diagrams describing a simple pattern; perform calculations including working with large numbers, calculations with speed and time, conversion of units (for example from an annual rate to a daily rate). They understand place value involving mixed 2- and 3-decimal values and including working with prices; and are typically able to order a small series of (4) decimal values; calculate percentages of up to 3-digit numbers; and apply calculation rules given in natural language.
2	At Level 2, students can typically interpret simple tables to identify and extract relevant quantitative information; interpret a simple quantitative model (such as a proportional relationship) and apply it using basic arithmetic calculations. They are able to identify the links between relevant textual information and tabular data to solve word problems; interpret and apply simple models involving quantitative relationships; identify the simple calculation required to solve a straight-forward problem; carry out simple calculations involving the basic arithmetic operations, as well as ordering 2- and 3-digit whole numbers and decimal numbers with one or two decimal places, and calculate percentages.
1a	At Level 1a, students are typically able to solve basic problems in which relevant information is explicitly presented, and the situation is straightforward and limited in scope. They are able to handle situations where the required computational activity is obvious and the mathematical task is basic, such as performing one or two simple arithmetic operations with whole numbers or percentages. Students at this level can manipulate quantitative information to make it amenable to computational analysis, such as determining the total number of points earned by teams given a record of their wins and losses.
1b	At Level 1b, students can solve straightforward problems that require single arithmetic operations with whole numbers or retrieving numerical information from a table or chart. For example, students can total the columns of a simple table and compare the results, or they can read and interpret a simple table of monetary amounts or a work schedule to satisfy a situation with a single constraint.
1c	*There were no items in the PISA 2022 Mathematics assessment to describe this level on the scale.*

Table I.A1.7. Proficiency levels on the mathematical content subscale: *Space and shape*

Level	What students can typically do
6	At Level 6, students are able to solve complex problems involving multiple representations or calculations; identify, extract, and link relevant information, for example by extracting relevant dimensions from a diagram or map and using scale to calculate an area or distance; they use spatial reasoning, significant insight and reflection, for example by interpreting text and related contextual material to formulate a useful geometric model and applying it taking into account contextual constraints; they are able to recall and apply relevant procedural knowledge from their mathematical knowledge base such as in circle geometry, trigonometry, Pythagoras's rule, or area and volume formulae to solve problems; and they are typically able to generalise results and findings, communicate solutions and provide justifications and argumentation.
5	At Level 5, students are typically able to solve problems that require appropriate assumptions to be made, or that involve reasoning from assumptions provided and taking into account explicitly stated constraints, for example in exploring and analysing the layout of a room and the furniture it contains. They solve problems using theorems or procedural knowledge such as symmetry properties, or similar triangle properties or formulas including those for calculating area, perimeter or volume of familiar shapes; they use well-developed spatial reasoning, argument and insight to infer relevant conclusions and to interpret and link different representations, for example to identify a direction or location on a map from textual information.
4	Students at Level 4 typically solve problems by using basic mathematical knowledge such as angle and side-length relationships in triangles, and doing so in a way that involves multistep, visual and spatial reasoning, and argumentation in unfamiliar contexts; they are able to link and integrate different representations, for example to analyse the structure of a three dimensional object based on two different perspectives of it; and typically they can compare objects using geometric properties.
3	At Level 3, students are able to solve problems that involve elementary visual and spatial reasoning in familiar contexts, such as calculating a distance or a direction from a map or a GPS device; they are typically able to link different representations of familiar objects or to appreciate properties of objects under some simple specified transformation; and at this level students can devise simple strategies and apply basic properties of triangles and circles, and can use appropriate supporting calculation techniques such as scale conversions needed to analyse distances on a map.
2	At Level 2, students are typically able to solve problems involving a single familiar geometric representation (for example, a diagram or other graphic) by comprehending and drawing conclusions in relation to clearly presented basic geometric properties and associated constraints. They can also evaluate and compare spatial characteristics of familiar objects in a situation where given constraints apply (such as comparing the height or circumference of two cylinders having the same surface area; or deciding whether a given shape can be dissected to produce another specified shape).
1a	Students at Level 1a can typically recognise and solve simple problems in a familiar context using pictures or drawings of familiar geometric objects and applying basic spatial skills such as recognising elementary symmetry properties, or comparing lengths or angle sizes, or using procedures such as dissection of shapes.
1b	*There were no items in the PISA 2022 Mathematics assessment to describe this level on the scale.*
1c	*There were no items in the PISA 2022 Mathematics assessment to describe this level on the scale.*

Table I.A1.8. Proficiency levels on the mathematical content subscale: *Uncertainty and data*

Level	What students can typically do
6	At Level 6, students are able to interpret, evaluate and critically reflect on a range of complex statistical or probabilistic data, information and situations to analyse problems. Students at this level bring insight and sustained reasoning across several problem elements; they understand the connections between data and the situations they represent and are able to make use of those connections to explore problem situations fully; they bring appropriate calculation techniques to bear to explore data or to solve probability problems; and they can produce and communicate conclusions, reasoning and explanations.
5	At Level 5, students are typically able to interpret and analyse a range of statistical or probabilistic data, information and situations to solve problems in complex contexts that require linking of different problem components. They can use proportional reasoning effectively to link sample data to the population they represent, can appropriately interpret data series over time and are systematic in their use and exploration of data. Students at this level can use statistical and probabilistic concepts and knowledge to reflect, draw inferences and produce and communicate results.
4	Students at Level 4 are typically able to activate and employ a range of data representations and statistical or probabilistic processes to interpret data, information and situations to solve problems. They can work effectively with constraints, such as statistical conditions that might apply in a sampling experiment, and they can interpret and actively translate between two related data representations (such as a graph and a data table). Students at this level can perform statistical and probabilistic reasoning to make contextual conclusions.
3	At Level 3, students are typically able to interpret and work with data and statistical information from a single representation that may include multiple data sources, such as a graph representing several variables, or from two simple related data representations such as a simple data table and graph. They are able to work with and interpret descriptive statistical, probabilistic concepts and conventions in contexts such as coin tossing or lotteries and make conclusions from data, such as calculating or using simple measures of centre and spread. Students at this level can perform basic statistical and probabilistic reasoning in simple contexts.
2	Students at Level 2 are typically able to identify, extract and comprehend statistical data presented in a simple and familiar form such as a simple table, a bar graph or pie chart; they can identify, understand and use basic descriptive statistical and probabilistic concepts in familiar contexts, such as tossing coins or rolling dice. At this level students can interpret data in simple representations, and apply suitable calculation procedures that connect given data to the problem context represented.
1a	At Level 1a, students can typically read and extract data from charts or two-way tables, and recognise how these data relate tothe context. Students at this level can also use basic concepts of randomness to identify misconceptions in familiar experimental contexts, such as flipping a coin.
1b	Students at Level 1b, can typically read information presented in a well-labelled table to locate and extract specific data values while ignoring distracting information.
1c	*There were no items in the PISA 2022 Mathematics assessment to describe this level on the scale.*

Indices from the student context questionnaire

In addition to scale scores representing performance in mathematics, reading and science, this volume uses indices derived from the PISA student questionnaires to contextualise PISA 2022 results or to estimate trends that account for demographic changes over time. The following indices and database variables are used in this report.

The PISA index of economic, social and cultural status (ESCS)

The PISA index of economic, social and cultural status (ESCS) is a composite score derived, as in previous cycles, from three variables related to family background: parents' highest level of education in years (PAREDINT), parents' highest occupational status (HISEI), and home possessions (HOMEPOS).

Parents' highest level of education in years: Students' responses to questions ST005, ST006, ST007 and ST008 regarding their parents' education were classified using ISCED-11 (UNESCO, 2012[3]). Indices on parental education were constructed by recoding educational qualifications into the following categories: (1) ISCED Level 02 (pre-primary education), (2) ISCED Level 1 (primary education), (3) ISCED Level 2 (lower secondary), (4) ISCED Level 3.3 (upper secondary education with no direct access to tertiary education), (5) ISCED Level 3.4 (upper secondary education with direct access to tertiary education), (6) ISCED Level 4 (post-secondary non-tertiary), (7) ISCED Level 5 (short-cycle tertiary education), (8) ISCED Level 6 (Bachelor's or equivalent), (9) ISCED Level 7 (Master's or equivalent) and (10) ISCED Level 8 (Doctoral or equivalent). Indices with these categories were provided for a student's mother (MISCED) and father (FISCED). In the event that student responses between ST005 and ST006 (for mother's education) or between ST007 and ST008 (for father's education) conflicted (e.g. in ST006 if a student indicated their parent having a postsecondary qualification but indicated in ST005 the parent had not completed lower secondary education), the higher education value provided by the student was used. This differs from the PISA 2018 procedure where the lower value was used. In addition, the index of highest education level of parents (HISCED) corresponded to the higher ISCED level of either parent. The index of highest education level of parents was also recoded into estimated number of years of schooling (PAREDINT). The conversion from ISCED levels to year of education is common to all countries. This international conversion was determined by using the cumulative years of education values assigned in PISA 2018 to each ISCED level. The correspondence is available in the *PISA 2022 Technical Report* (OECD, Forthcoming[2]).

To make PAREDINT scores for PISA 2012, PISA 2015, and PISA 2018 comparable to PAREDINT scores for PISA 2022, new PAREDINT scores were created for each student who participated in previous cycles using the coding scheme used in PISA 2022. These new PAREDINT scores were used in the computation of trend ESCS scores.

Parents' highest occupational status: Occupational data for both the student's father and the student's mother were obtained from responses to open-ended questions. The responses were coded to four-digit ISCO codes (ILO, 2007) and then mapped to the international socio-economic index of occupational status (ISEI) (Ganzeboom and Treiman, 2003[4]). In PISA 2022, the ISCO and ISEI in their 2008 version were used. Three indices were calculated based on this information: father's occupational status (BFMJ2); mother's occupational status (BMMJ1); and the highest occupational status of parents (HISEI), which corresponds to the higher ISEI score of either parent or to the only available parent's ISEI score. For all three indices, higher ISEI scores indicate higher levels of occupational status.

Home possessions (HOMEPOS) is a proxy measure for family wealth. In PISA 2022, students reported the availability of household items at home, including books at home and country-specific household items that were seen as appropriate measures of family wealth within the country's context. HOMEPOS is a summary index of all household and possession items (ST250, ST251, ST253, ST254, ST255, ST256). Some HOMEPOS items used in PISA 2018 were removed in PISA 2022 while new ones were added (e.g., new items developed specifically with low-income countries in mind). Furthermore, some HOMEPOS that were previously dichotomous (yes/no) items were revised to polytomous items (1, 2, 3, etc.) allowing for capturing a greater variation in responses.

For the purpose of computing the PISA index of economic, social and cultural status (ESCS), values for students with missing PAREDINT, HISEI or HOMEPOS were imputed with predicted values plus a random component based on a regression on the other two variables. If there were missing data on more than one of the three variables, ESCS was not computed and a missing value was assigned for ESCS.

In PISA 2022, ESCS was computed by attributing equal weight to the three standardised components. The three components were standardised across the OECD countries, with each OECD country contributing equally. The final ESCS variable was transformed, with 0 the score of an average OECD student and 1 the standard deviation across equally weighted OECD countries.

Immigrant background (IMMIG)

Information on the country of birth of the students and their parents was collected. Included in the database are three country-specific variables relating to the country of birth of the student, mother and father (ST019). The variables are binary and indicate whether the student, mother and father were born in the country of assessment or elsewhere. The index on immigrant background (IMMIG) is calculated from these variables, and has the following categories: (1) native students (those students who had at least one parent born in the country); (2) second-generation students (those born in the country of assessment but whose parent[s] were born in another country); and (3) first-generation students (those students born outside the country of assessment and whose parents were also born in another country). Students with missing responses for either the student or for both parents were given missing values for this variable.

Language spoken at home (ST022)

Students indicated what language they usually spoke at home, and the database includes an internationally comparable variable (ST022Q01TA) that was derived from this information and has the following categories: (1) language at home is same as the language of assessment for that student; (2) language at home is another language.

The mappings of options provided in national versions of the student questionnaire for the two possible values for the “International Language at Home” variable (ST022Q01TA) are the responsibility of national PISA centres. For example, for students in the Flemish Community of Belgium, “Flemish dialect” was considered (together with “Dutch”) as equivalent to the “Language of test”; for students in the French Community and German-speaking Community (respectively), Walloon (a French dialect) and a German dialect were considered to be equivalent to “Another language”.

Mathematics Anxiety (ANXMAT)

The index of mathematics anxiety (ANXMAT) was constructed using student responses to question (ST345) over the extent they strongly agreed, agreed, disagreed or strongly disagreed with the following statements when asked to think about studying mathematics: “I often worry that it will be difficult for me in mathematics classes”; “I get very tense when I have to do mathematics homework”; “I get very nervous doing mathematics problems”; “I feel helpless when doing a mathematics problem”; “I worry that I will get poor <grades> in mathematics”; and “I feel anxious about failing in mathematics”.

In addition to the indices listed above, the following database variables were used in this report.

- Student gender (ST004)
- Age of arrival in country of test (ST021) (only for students who were born in a country that is different of the country of test)
- Food insecurity (ST258)

Notes

[1] “Unlikely”, in this context, refers to a probability below 62%.

[2] The standard deviation of 100 score points corresponds to the standard deviation in a pooled sample of students from OECD countries, where each national sample is equally weighted.

References

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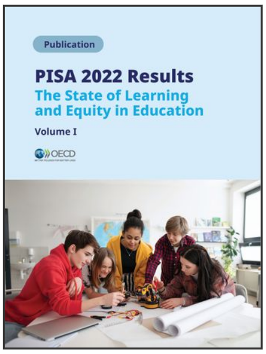

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