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PIAAC
CYCLE 2

PIAAC Cycle 2 Released Cognitive Items

Doc.: *PIAAC Cycle 2 Released Cognitive Items*

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ets cApStAn linguistic quality control GESIS Leibniz Institute for the Social Sciences IEA Maastricht University Research Centre for Education and the Labour Market / ROA Westat

Contents

Section 1: Introduction

This report presents and describes literacy, numeracy, and adaptive problem-solving items approved for release from the second cycle of the OECD's *Programme for the International Assessment of Adult Competencies* (PIAAC Cycle 2). A screenshot of each item is included, and following each screenshot is a description of the question the respondent answered, information on ways that respondents could have solved each problem, information on the cognitive process represented, and where applicable, details on item functionality. Classification information from the framework (e.g., content area, process, context, etc.), the item format, the correct answer(s), and, if known, the proficiency level (i.e., the level at which students are expected to have a 0.67 probability of responding correctly to the item), are included in a table following each description. Note that some of the items in this report were not administered in either the field trial or main survey, so the difficulty levels are estimated.

About PIAAC and Cycle 2

PIAAC is an international assessment of the information-processing skills of adults. It assesses three broad skills: reading and understanding written texts (literacy), understanding and using mathematical and numerical information (numeracy), and solving problems. It also includes a comprehensive background questionnaire that is administered in conjunction with the assessment. The study is designed as a repeated cross-sectional study that provides comparable estimates of proficiency in literacy and numeracy over time.

PIAAC is the third in a series of international adult assessments conducted since the mid-1990s. It builds on the experience of the International Adult Literacy Survey (IALS) and the Adult Literacy and Life Skills Survey (ALL). IALS collected data in three waves between 1994 and 1998 in 22 countries and regions. ALL collected data in two waves over the period 2002-2008 in 11 countries and regions. The first cycle of the PIAAC assessment took place over the period 2008-2019 with three data collection rounds: the first in 2011-12, the second in 2014-15 and the third in 2017-18. A total of 39 countries/regions participated in the first cycle and 31 participated in the second cycle. Of the 31 countries/regions that participated in the second cycle, 27 also participated in at least one of the rounds of the first cycle. Data for Cycle 2 were collected in 2022-23 following a one-year delay because of the Covid-19 pandemic.

Data were collected in PIAAC using a combination of a personal interview and a self-completed assessment. Data collection took place in the respondent's own home under the supervision of trained interviewers. The background questionnaire was administered in Computer Aided Personal Interview (CAPI) mode by the interviewer. Following completion of the background questionnaire, the respondent completed the assessment under the supervision of the interviewer. In PIAAC Cycle 2, the assessment was administered following a tablet-only design after data from the field trial confirmed that the vast majority of respondents across age, skill and other background variables could use the tablet. The assessment interface was designed in such a way as to ensure that most, if not all, respondents would be able to take the assessment on the tablet even if they had limited experience with such devices.

Instrumentation and Design

As noted previously, respondents first complete a background questionnaire. The background questionnaire in PIAAC Cycle 2 consists of 11 modules collecting information on demographic characteristics, social and language background, education, labour-force participation, employment, the task composition of the respondent's job, literacy and numeracy practices at work and/or in everyday life and their social-emotional skills.

The direct (i.e., cognitive) assessment involves the following components:

- a locator test
- an administration of reading and numeracy components
- assessments of literacy, numeracy, and adaptive problem solving

The locator test consists of eight literacy and eight numeracy items of low difficulty. It is designed to provide an initial estimate of the proficiency of the respondent. This is used to direct the respondent to the testing pathway appropriate to his/her proficiency (see Figure 1 below).

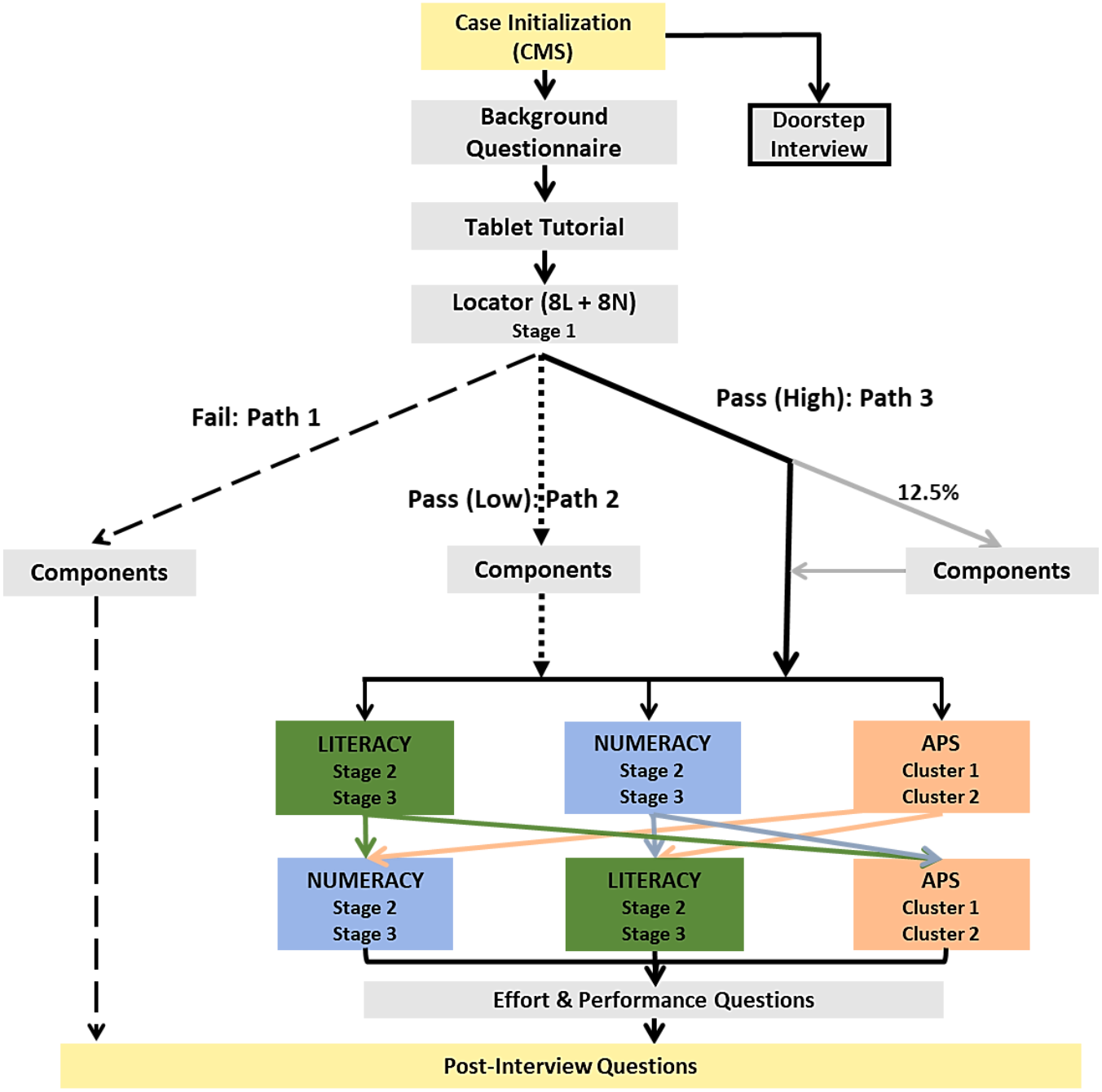
The reading and numeracy components assessment consists of a set of items assessing:

- the ability to understand the meaning of simple sentences and to read and understand short passages fluently (reading)
- understanding basic notions of quantity and magnitude (numeracy).

In each domain, the assessment consists of units, and each unit is made up of one or more stimuli (e.g., a description of a problem situation, a text, a table, a simulation, etc.) and a set of questions or tasks based on the stimuli. For the main survey, the literacy assessment contained 28 units (80 items), the numeracy assessment contained 49 units (80 items), and the adaptive problem-solving assessment contained 15 units (65 items). Additionally, for literacy, 35% of the items were trend, and for numeracy, 40% of the items were trend. Trend items are items administered in a previous cycle and are used for linking to previous international adult assessments. Adaptive problem-solving is a new domain for cycle 2, so all items were new with no link to previous assessments.

Each respondent who passes the locator is administered test items covering two of the three domains and in each of these domains, he or she is administered a subset of the test items. In all three domains, the assessments use an adaptive design. The goal is to maximise the efficiency and precision of the assessment by presenting respondents with test items that are neither too easy nor too difficult for them. Respondents who do not pass the Locator only receive reading and numeracy components. This allows them to demonstrate their skills on very easy items without burdening them with more difficult items that could be outside their skill level.

Figure 1: PIAAC Cycle 2 – Main Survey Assessment Design



Section 2: Organisation of the Domains

Below is a brief summary of each domain, including how each domain is defined for PIAAC Cycle 2 and a short description of its major dimensions. For more detailed information on each domain, please refer to the latest version of the framework document available on the OECD's website: www.oecd.org/skills/piaac/publications/.

Within each domain, every item is assigned a classification for each of the major dimensions of that domain. There can sometimes be overlap with the classifications, but each item is given a classification based on the most prevalent cognitive aspects of the item and the stimulus material.

Literacy

In PIAAC Cycle 2, literacy is defined as: accessing, understanding, evaluating and reflecting on written texts in order to achieve one's goals, to develop one's knowledge and potential and to participate in society.

The domain is then further broken down into three core dimensions: cognitive processes, texts, and social contexts.

Cognitive Processes

- *Accessing text* – encompasses a number of literacy processes whereby readers examine the text(s) available, select the most relevant text, scan contents in search for specific pieces of information and locate these pieces through various types of cues.
- *Understanding* – involves the parsing and integration of one or several extended passage(s) of text in order to form a complete representation of what the text is about and involves literal or inferential comprehension (including inferential comprehension across multiple texts).
- *Evaluating* – attending to and assessing the accuracy, soundness, and task relevance of a text, specifically the content or the source of the text.

Texts

- Types
  - *Description* – refers to properties of objects in space.
  - *Narration* – refers to properties of characters and objects in time.
  - *Exposition* – text to communicate concepts, phenomena and other mental constructs involving a set of interacting elements.
  - *Argumentation* – presents factual or interpretive claims about a situation, together with supporting reasons and warrants.
  - *Instruction* – provides directions on what to do. Sometimes called injunction.
  - *Transaction* – written text that supports interpersonal communication, such as requesting that something is done, organising a meeting or making a social engagement with a friend.
- Formats
  - *Continuous* – sequences of sentences and paragraphs.
  - *Non-continuous* – words, sentences or passages organised in a list or matrix format.
  - *Mixed* – involve both continuous and non-continuous text.

- Organisation
  - Refers to the amount of information (number of pages) and the density of content representation and access devices.
- Source
  - *Single* – texts that originate in a single source, i.e., an author, a publication medium, and a date of publication.
  - *Multiple* – have different authors or were published through different channels or at different times.

Social Contexts

- *Work and occupation* – can include text(s) related to finding employment, finance, and being on the job (i.e., regulations, organisation, safety instructions), but without using specialized, job-specific text requiring prerequisite knowledge.
- *Personal use* – can include text(s) related to interpersonal relationships, personal finance, housing, insurance, health and safety issues, consuming habits, or organising leisure and recreation time.
- *Social and civic* – can include text(s) related to community resources, public services, staying informed, and education and training.

Numeracy

In PIAAC Cycle 2, numeracy is defined as: accessing, using, and reasoning critically with mathematical content, information and ideas represented in multiple ways in order to engage in and manage the mathematical demands of a range of situations in adult life.

The domain is then further broken down into four core dimensions: cognitive processes, mathematical content, representations, and contexts.

Cognitive Processes

- *Access and assess situations mathematically* – involves first deciding if mathematics is an appropriate means to engage with a situation, and if it is, then identifying the essential features to be accommodated when transforming the real-world situation into a problem that can be represented and solved mathematically.
- *Act on and use mathematics* – involves utilising mathematical processes, facts and procedures in order to derive results and solve real-world problems, including selecting and using appropriate tools and technology.
- *Evaluate, critically reflect, make judgements* – involves evaluating a solution to a real-world problem against the original problem situation in terms of its reasonableness and relevance to the original context, and deciding whether to accept the solution or to revise and adjust it.

Mathematical Content

- *Quantity and number* – involves understanding ordering, counts, place value, magnitudes, indicators, relative size, and numerical trends, as well as aspects of quantitative reasoning, such as multiple representations, estimation, and judging the reasonableness of results.
- *Space and shape* – involves understanding and using measurement (informal and standardised) systems, measurement formulas; scales; dimensions and units; location and direction; geometric shapes and patterns; angle properties; symmetry; transformations and 2D and 3D representations and perspectives.
- *Change and relationships* – involves ways to describe, model and interpret mathematical relationships, quantitative patterns, and change, where they occur in the real world. Relationships may be linear or non-linear.
- *Data and chance* – involves topics such as data collection, data displays, charts and graphs, measures of central tendency and variance, alongside understanding appropriate approaches to data collection and sampling. It also includes understanding subjective probability, certainty and uncertainty, likelihood and unlikelihood, prediction, and decision making.

Representations

- *Text or symbols* – the stimulus is primarily based on running text that describes the problem situation and can include symbols and numerical information integrated into the text.
- *Images of physical objects* – the stimulus is primarily based on photos or images of physical objects which depict the problem situation.
- *Structured information* – the stimulus is primarily based on data or information that is represented in tables, graphs/charts, maps, plans, calendars, schedules, timetables, infographics, etc. Text is also often included to help specify and describe the information and the problem situation.
- *Dynamic applications* – the stimulus is primarily based on interactive applications, animations, calculation applications, or simulations.

Contexts

- *Personal* – focuses on mathematical activities for an individual and in their interactions with immediate family.
- *Work* – involves mathematical situations encountered in the workplace, and can include any level of the workforce, from unskilled work to the highest levels of professional work.
- *Societal/Community* – involves the application of mathematics to events happening in the world at the local, national or global level.

Adaptive Problem Solving

In PIAAC Cycle 2, adaptive problem solving is defined as: the capacity to achieve one's goals in a dynamic situation, in which a method for solution is not immediately available. It requires engaging in cognitive and metacognitive processes to define the problem, search for information, and apply a solution in a variety of information environments and contexts.

The domain is then further broken down into three core dimensions: cognitive processes (cognitive and metacognitive), task dimensions, and contexts.

Cognitive Processes

- Defining
  - *Selecting, organising, and integrating information into mental model* – constructing a mental representation of the problem space (initial state, goal state, legal operators).
  - *Retrieving relevant background information* – accessing memory to retrieve background knowledge (note: assessment tasks should be designed to avoid necessity of this process).
  - *Externalising internal problem representation* – creating an external representation (e.g., drawing, table) that illustrates the problem solver's mental model of the problem.
- Searching
  - *Searching for operators in the mind and environment* – locating information about available action options that might be suited to solve the problem.
  - *Evaluating operators with respect to how well they satisfy problem constraints* – determining which of the action options will be best to reach the goal while considering all possible constraints.
- Application
  - *Applying plans and executing operators* – implementing the selected operator(s) to solve the problem.

Metacognitive Processes

- Defining
  - *Goal setting* – deciding upon what the to-be-achieved state is about (cannot be considered in large-scale assessments because allowing problem solvers to set their own goals would yield too many degrees of freedom).
  - *Monitoring problem comprehension* – supervising whether one's mental model of the problem matches the current state of affairs.
- Searching
  - *Evaluating operators with respect to whether they can be executed* – determining which of the action options will be best to reach the goal while considering all possible constraints.
- Application
  - *Monitoring progress* – determining whether executing operators achieves the desired outcome.
  - *Regulating application of operators* – modifying selection of operators in case the problem configuration has changed (cf. monitoring problem comprehension) or impasses have been noted (cf. monitoring progress).
  - *Reflection* – deliberating about one's own capabilities to solve problems with the goal of abstracting knowledge from it that can be applied in the future (cannot be considered in a large-scale assessment context because it requires repeated confrontation with similar problem-solving instances).

Task Dimensions

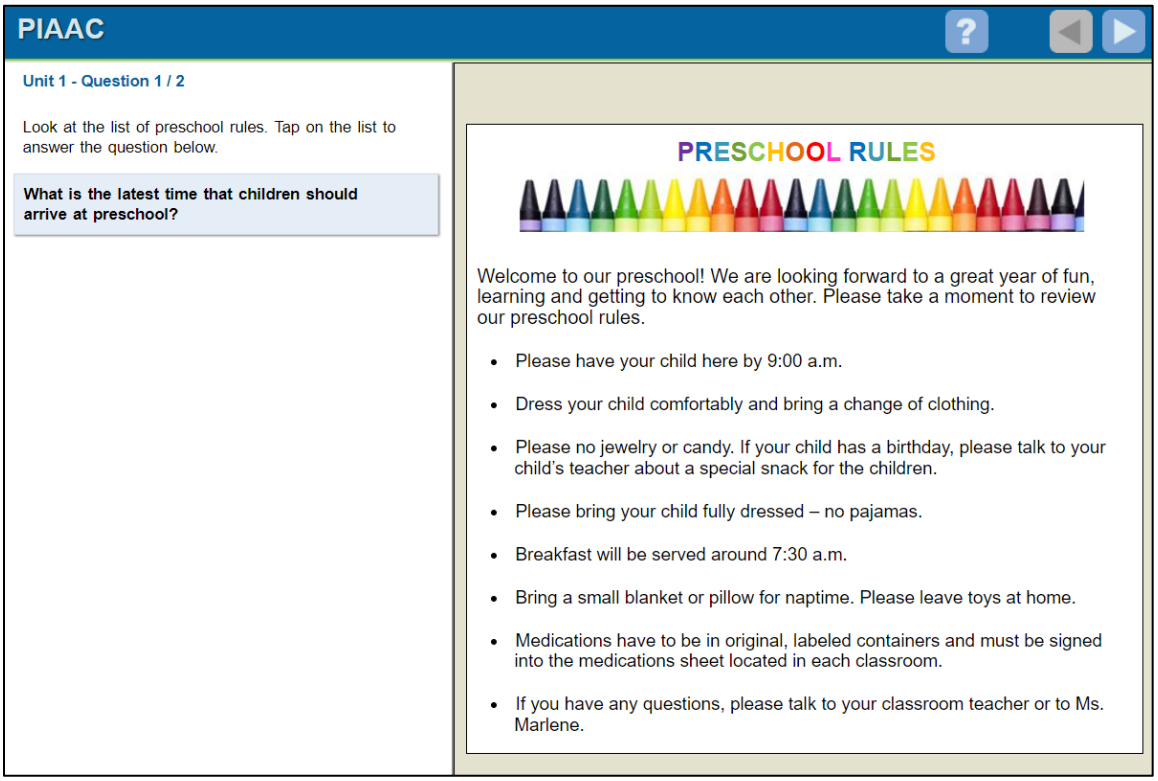
- *Problem configuration* – refers to the initial problem setup and the goal state(s) including the problem elements, the relations, and the resources/operators.
- *Dynamics of the situation* – refers to change (or absence of change) within the problem situation and the problem constraints across time, and how this affects the problem configuration.
- *Features of the environment* – refers to various features that are characteristic of the environment and the information and resources available from it.
- *Information environment* – refers to the sources for the resources that are available for solving the problem. The nature of the information environment can be physical, social, or digital.

Contexts

- *Personal* – may refer to one's home, family, career, education, hobbies, or financial investments; these problems will therefore require problem solvers to solve a problem that occurs in the context of their personal life.
- *Work* – may require problem solvers to solve a work-related task, or place them in a work-related context, in which they work under supervision or with co-workers.
- *Societal/Community* – may refer to interaction with other people in leisure activities (e.g., going to a party or hiking in the mountains) or with community resources (e.g., police, firefighters, or administrative institutions).

Section 3: Literacy Items

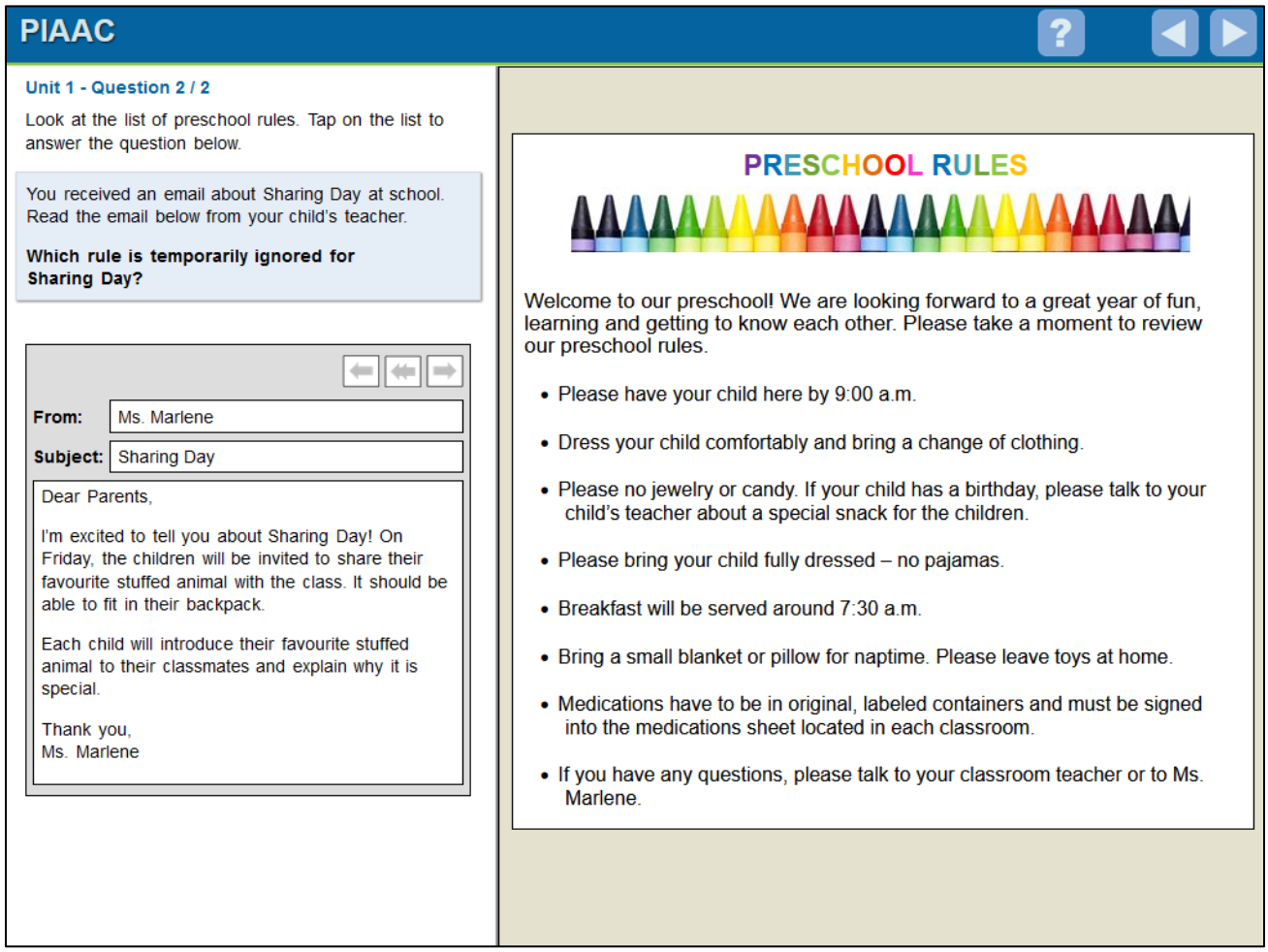
Unit 580 – Preschool Rules – Item 1



This is the first item in a unit called Preschool Rules. The stimulus for this first item is a list of rules intended for parents of preschool students. This item was designed to be of low difficulty. The difficulty of the items in this unit are estimated because this unit was not tested in the field trial or main study of Cycle 2. The cognitive process measured by this item is Accessing Text because a scan of the text for time information can easily take the reader to the first rule (Please have your child here by 9:00 a.m.). Once the appropriate rule has been identified, the respondent needs to tap on the rule to select it. The cognitive process, Understanding, is also represented in this item because there is another rule that refers to a time (the fifth rule: Breakfast will be served around 7:30 a.m.). Readers must understand that the first rule is the one that answers the question, however, searching and scanning the text for information, or Accessing Text, is the primary process.

Unit Name – Item #	**Preschool Rules – Item 1**
Process	Accessing Text
Source	Single
Context	Personal
Item Format	Tap on Stimulus
Answer	The first rule: Please have your child here by 9:00 a.m.
Estimated Difficulty	Low

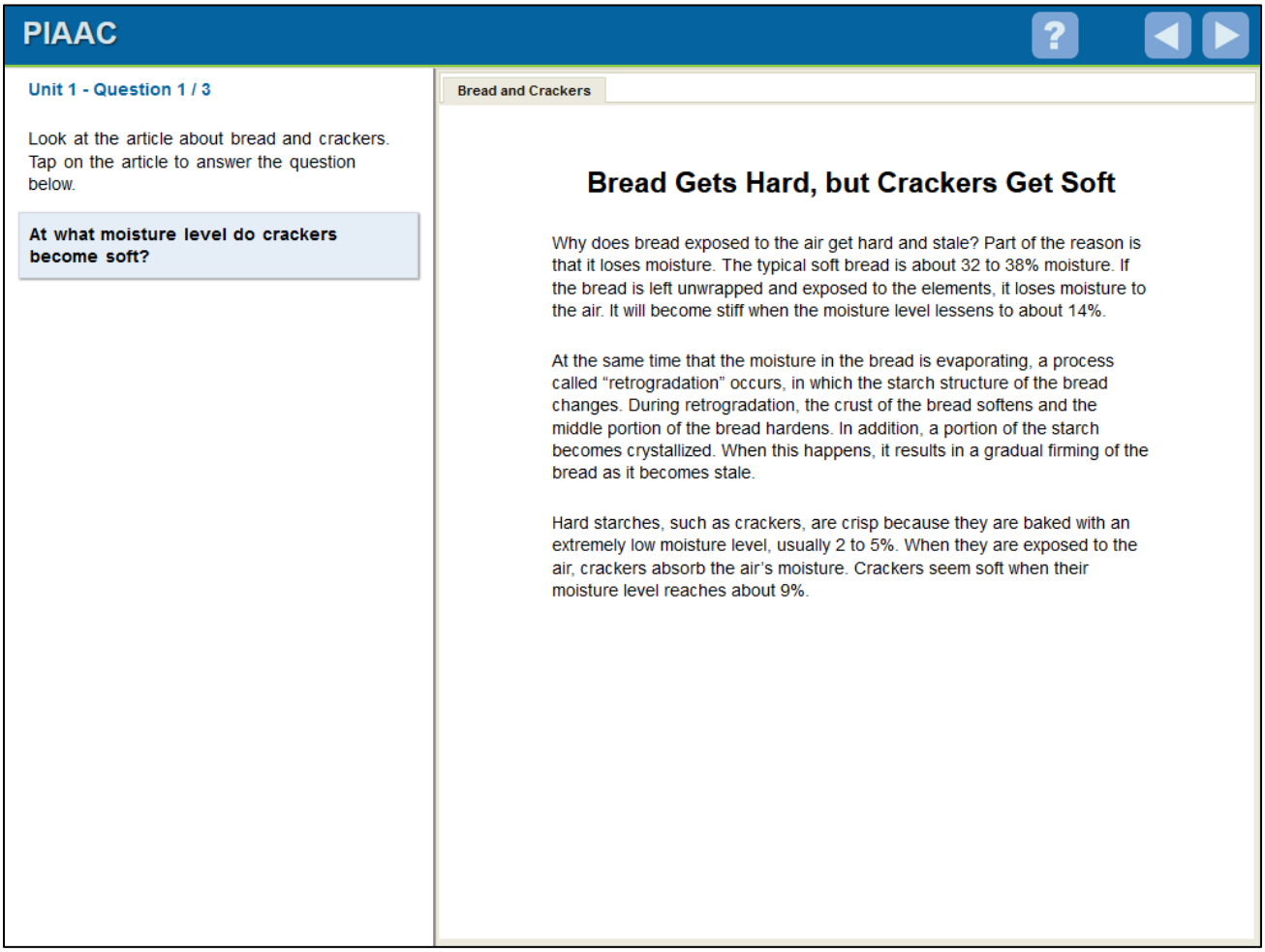
Unit 580 – Preschool Rules – Item 2



In this item, a second stimulus appears in the form of an email from a teacher, explaining that students can bring a stuffed animal to school for Sharing Day. The item asks the respondent to identify the rule that is temporarily ignored for Sharing Day. This item is classified as an Understanding item, because the respondent must integrate information from multiple texts: the new text in the email, and the old text (i.e., the Preschool Rules). This is a process of inferential comprehension across multiple texts, and it is one aspect in which the Cycle 2 Literacy framework expanded the construct of Literacy beyond the framework used in Cycle 1 of PIAAC. The correct answer is the sixth rule from the top (Bring a small blanket or pillow for naptime. Please leave toys at home.) which can be ignored for this special event as the email specifies that children are allowed to bring their favourite stuffed animal to school. This item was developed to be moderately difficult because the reader must contend with the information presented in two texts, and the conflicting information does not use identical language. That is, the reader must infer that a "stuffed animal" is a type of "toy," in order to identify the appropriate rule. Lastly, the rule to be ignored contains additional text the reader must ignore because it is irrelevant to this specific question.

Unit Name – Item #	**Preschool Rules – Item 2**
Process	Understanding
Source	Multiple
Context	Personal
Item Format	Tap on Stimulus
Answer	The sixth rule: Bring a small blanket or pillow for naptime. Please leave toys at home.
Estimated Difficulty	Moderate

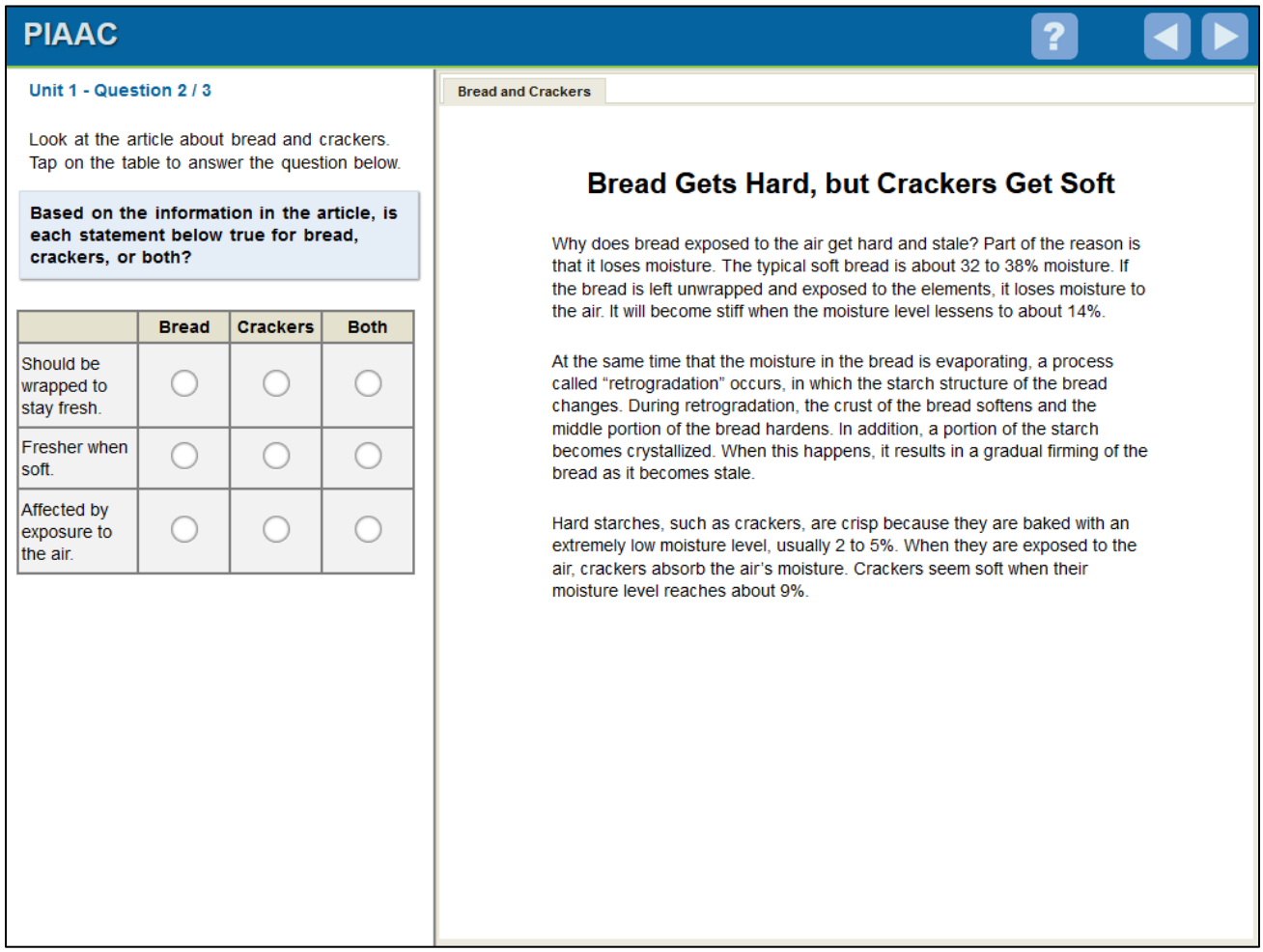
Unit 581 – Bread – Item 1



This is the first item in a unit called Bread. The stimulus for this first item is a brief article about why bread and crackers have different textures and how each are affected by exposure to moisture. This item was designed to be of low difficulty and represents the cognitive process of Accessing Text. The difficulty of the items in this unit are estimated because this unit was not tested in the field trial or main study of Cycle 2. To answer this item correctly, the respondent can scan for "moisture" and "crackers." The effects of moisture on bread are discussed in the first paragraph, and the second paragraph briefly describes the scientific process that occurs when bread becomes stale. Crackers are not discussed until the third paragraph. Thus, respondents need to recognise that the first and second paragraphs are missing information on crackers and continue to scan.

Unit Name – Item #	**Bread – Item 1**
Process	Accessing Text
Source	Single
Context	Personal
Item Format	Sentence Selection
Answer	Third sentence of third paragraph: Crackers seem soft when their moisture level reaches about 9 percent.
Estimated Difficulty	Low

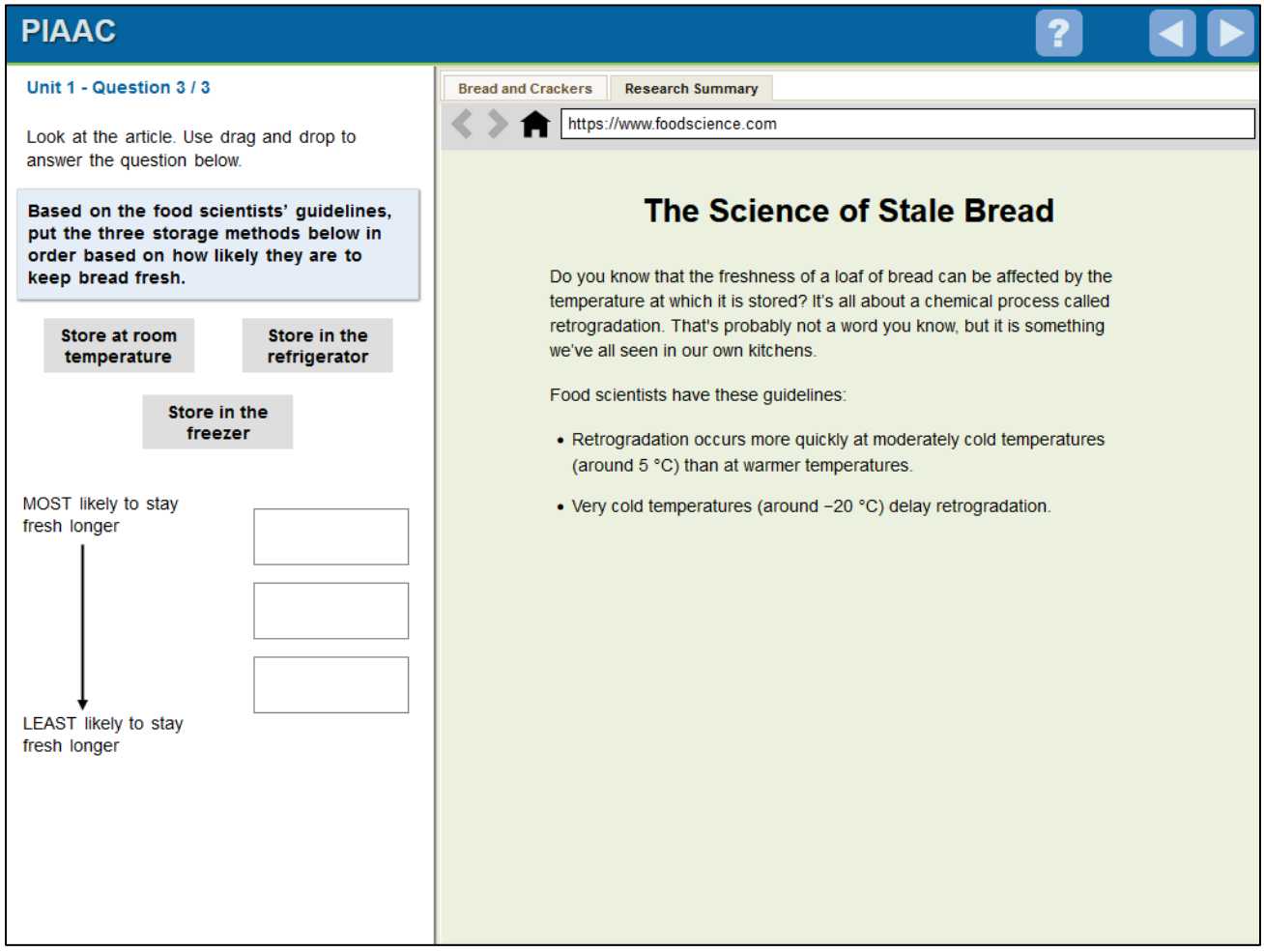
Unit 581 – Bread – Item 2



The second item in the unit requires the respondent to complete a table. Each row contains a statement, and the respondent must indicate whether the statement is true for bread, for crackers, or for both. To complete this item correctly, respondents must go beyond a literal understanding of the explicitly stated information. They must integrate and understand the information across the entire article. For example, to understand that the first statement, "Should be wrapped to stay fresh" is true for both bread and crackers, information from the first and third paragraphs needs to be integrated. Furthermore, the first statement does not appear directly in the text, so the reader needs to infer the connection between the statement and the action that can be taken to reduce the effects of moisture. The underlying cognitive process is Understanding because the item requires inferential comprehension. This item was designed to be of moderate to high difficulty, considering the amount of information that must be inferred and understood. To receive full credit for this item, all three rows of the table need to be correct. There is no partial credit for this item.

Unit Name – Item #	**Bread – Item 2**
Process	Understanding
Source	Single
Context	Personal
Item Format	Complex Multiple Choice
Answers	<u>All 3 correct selections (from top to bottom of table):</u> Both Bread Both
Estimated Difficulty	Moderate to high

Unit 581 – Bread – Item 3



This is the last item in the unit Bread. Like the previous one, this item is classified as an Understanding item because it requires inferential comprehension. To complete this item, the respondent must drag the grey boxes and place them in the correct order from most likely to least likely to stay fresh longer. The brief article does not explicitly mention storage locations such as refrigerators or freezers. Thus, the respondent must infer which storage location is most similar to the moderately cold temperatures mentioned in the first bullet, and which location is similar to the very cold temperatures mentioned in the second bullet. Room temperature is not mentioned at all, but by integrating the information in the two bullets, respondents must figure out that room temperature falls between the very cold temperatures that delay retrogradation and the moderately cold temperatures that cause retrogradation to occur more quickly. Therefore, a correct response from most to least likely is: store in the freezer, store at room temperature, and store in the refrigerator. The stimulus shown here specifies temperature in degrees Celsius, but an Imperial version was created for those countries that use Imperial measurements as their standard. In that version, retrogradation occurs more quickly at around 40º Fahrenheit, and retrogradation is delayed at very cold temperatures around 0º Fahrenheit. This item was designed as moderate to high difficulty because of the inferential comprehension demands. For full credit, all three storage methods must be placed in the correct order. There is no partial credit for this item.

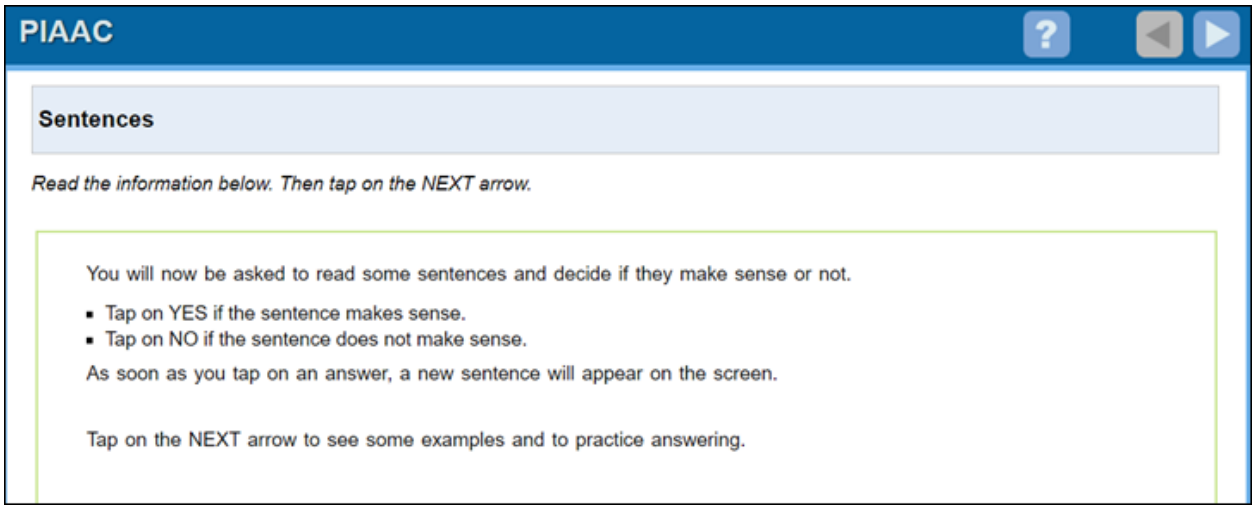
Unit Name – Item #	**Bread – Item 3**
Process	Understanding
Source	Single
Context	Personal
Item Format	Drag and drop
Answers	Correct order (from most to least likely): Store in the freezer (most) Store at room temperature Store in the refrigerator (least)
Estimated Difficulty	Moderate to high

Section 4: Reading Components Items

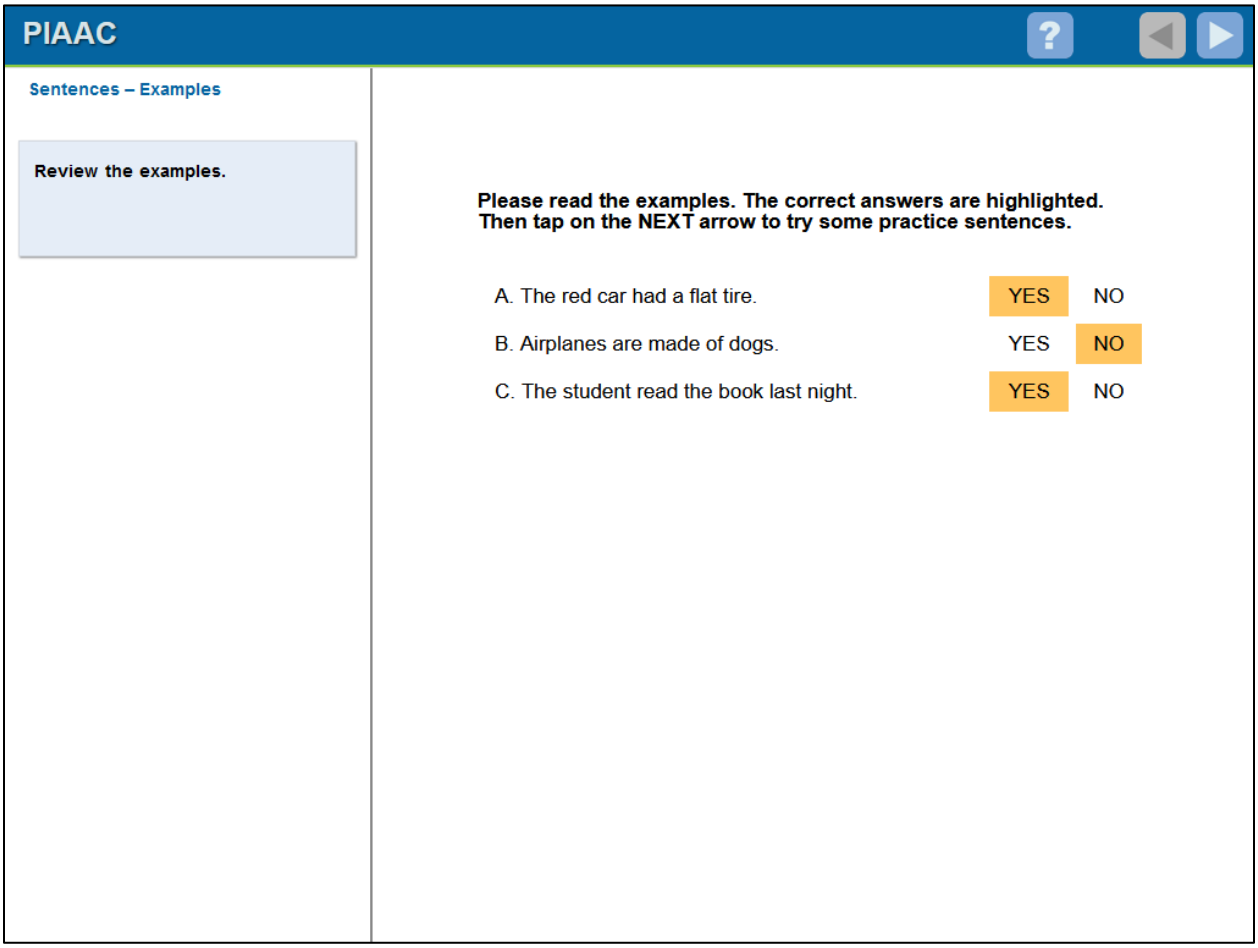
The Reading Components tasks are very easy comprehension tasks containing a limited amount of text. The two tasks are: Sentence Processing, where the respondents must indicate if a sentence makes sense or not, and Passage Fluency, where respondents must choose the word that best completes a sentence.

In both tasks, respondents with adequate literacy skills should be able to respond quickly and accurately. Respondents with Literacy skills characterised as “Below Level 1” or “Level 1” on the Literacy proficiency scale may find some items more difficult. Performance on the Components tasks is used along with performance on the Literacy tasks to describe the Literacy proficiency scale. These component tasks are particularly useful for describing the skills of adults at the lowest levels of the Literacy scale.

Sentence Processing



This is the introduction screen that explains the Sentence Processing task (which is called “Sentences” in the version respondents saw). In this task, sentences are presented, one at a time on the screen. Respondents are asked to indicate whether the sentence makes sense (by tapping on YES) or whether it does not make sense (by tapping on NO). Next, respondents see a set of static practice items and then a short set of dynamic practice items. The static practice presents three example items with the correct answers already selected so respondents can better understand the task. An image of the three static practice examples is shown below.



After the static practice items, respondents are given a set of dynamic practice items for additional practice with the response format and presentation of the items. The three dynamic practice sentences are listed below. The correct response is shown in brackets next to each sentence.

- Six birds flew over the trees. [YES]
- The window sang the song loudly. [NO]
- The man drove the car to the store. [YES]

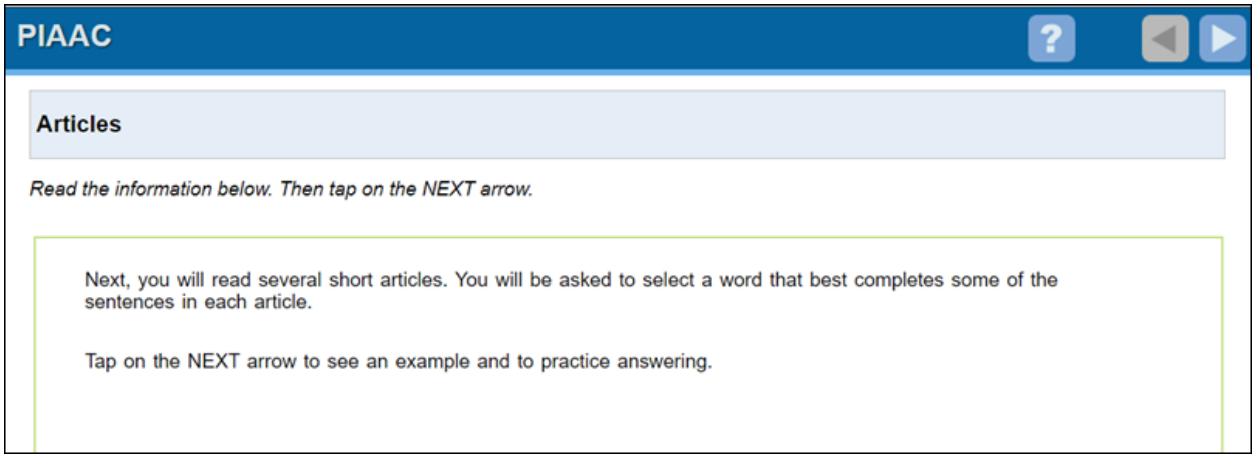
After the dynamic practice, respondents are informed that they have completed the practice and the first set of items begins. The set of five items shown below is a shorter version of the Sentences task administered in PIAAC Cycle 2. The correct response is shown in brackets next to each sentence.

1) The soft kitten purred. [YES]
2) Two boys threw the wall. [NO]
3) The strong person moved the heavy rock. [YES]
4) A comfortable pillow is soft and rocky. [NO]
5) A person who is twenty years old is older than a person who is thirty years old. [NO]

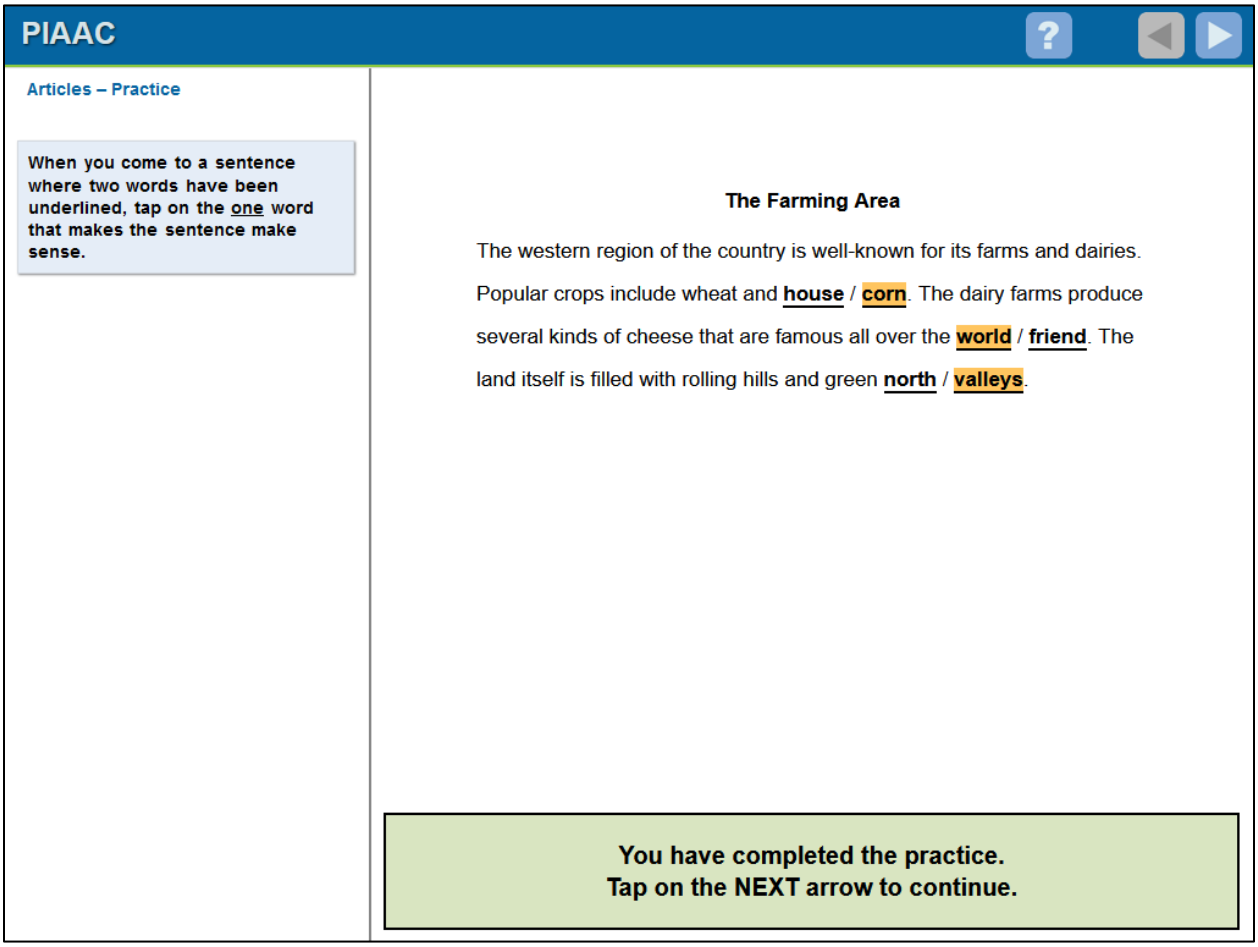
Overall, these sentences should be very easy, but there are some slight variations in difficulty and complexity. The first two sentences are short and have simple syntax. The third and fourth sentences are longer and have more syntactic features, primarily more adjectives to describe the main nouns in the sentence. The fifth sentence is one of the most complex and likely most difficult sentences. It is long and has two embedded clauses, increasing the amount of information a respondent must consider when making a judgment about whether the sentence makes sense. Nevertheless, all items in the Sentences task are classified as Below Level 1 on the Literacy proficiency scale.

Passage Fluency

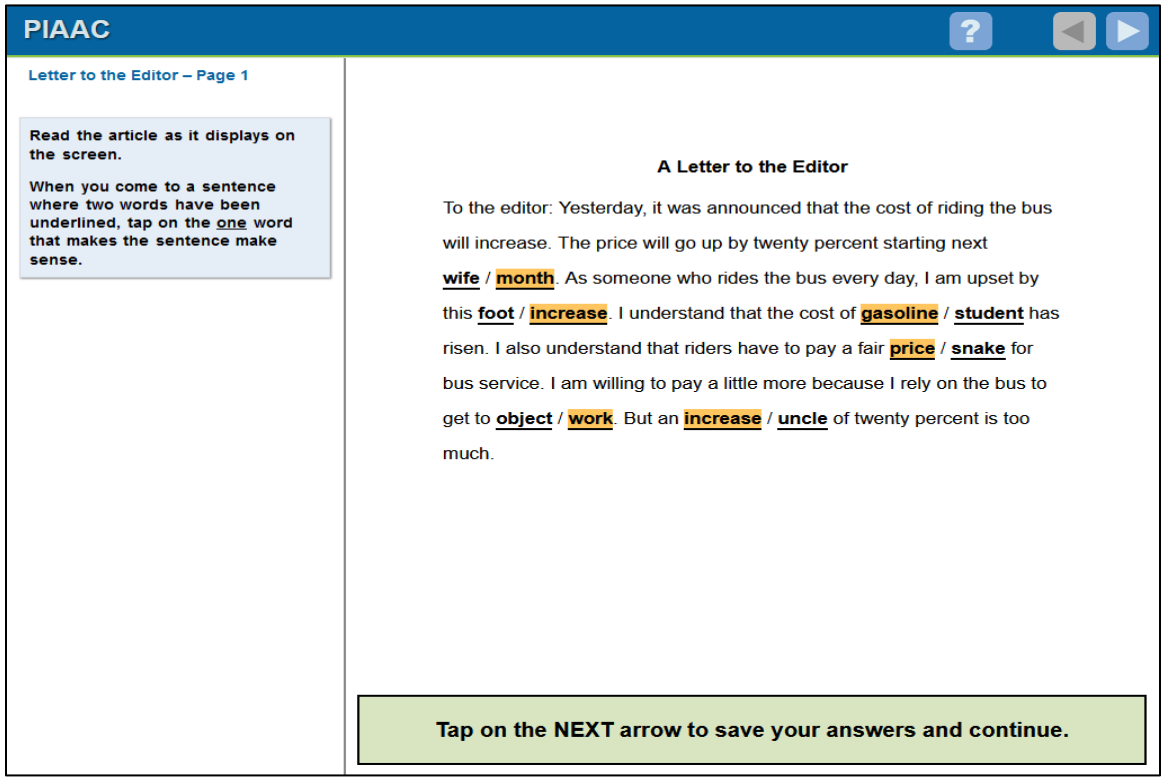
In the Passage Fluency tasks (which is called “Articles” in the version respondents saw), short articles or passages are presented one sentence at a time. In some sentences, the respondent is asked to choose the word that best completes the sentence. Responses are made by tapping on the word that fits best. This continues until the article is complete. Most articles have several pages, but all articles are relatively short. Each article was designed to be fairly easy to read, avoiding very long sentences and difficult vocabulary.

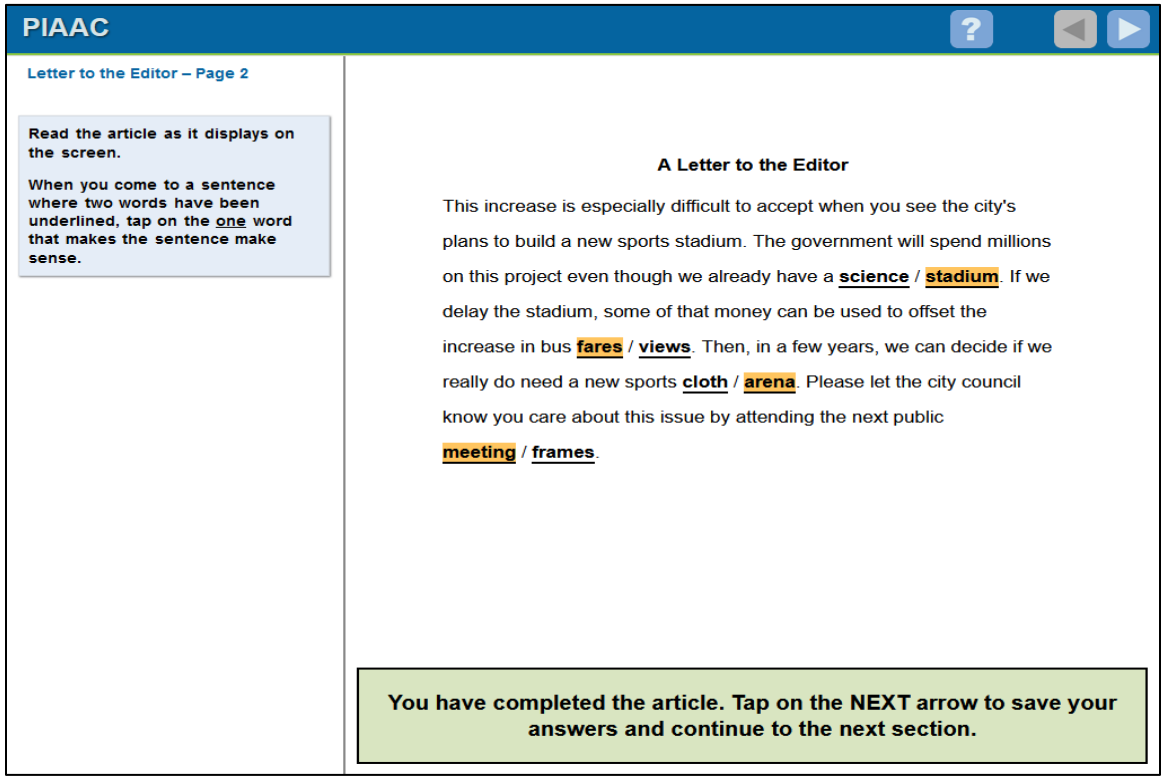


This is the introduction screen that provides a general description of the task. The next screen presents dynamic practice that allows respondents to practice choosing the best word to complete several sentences, in order to become more familiar with the format of the actual task. An image of the dynamic practice article, *The Farming Area*, is shown below with the correct words already selected.



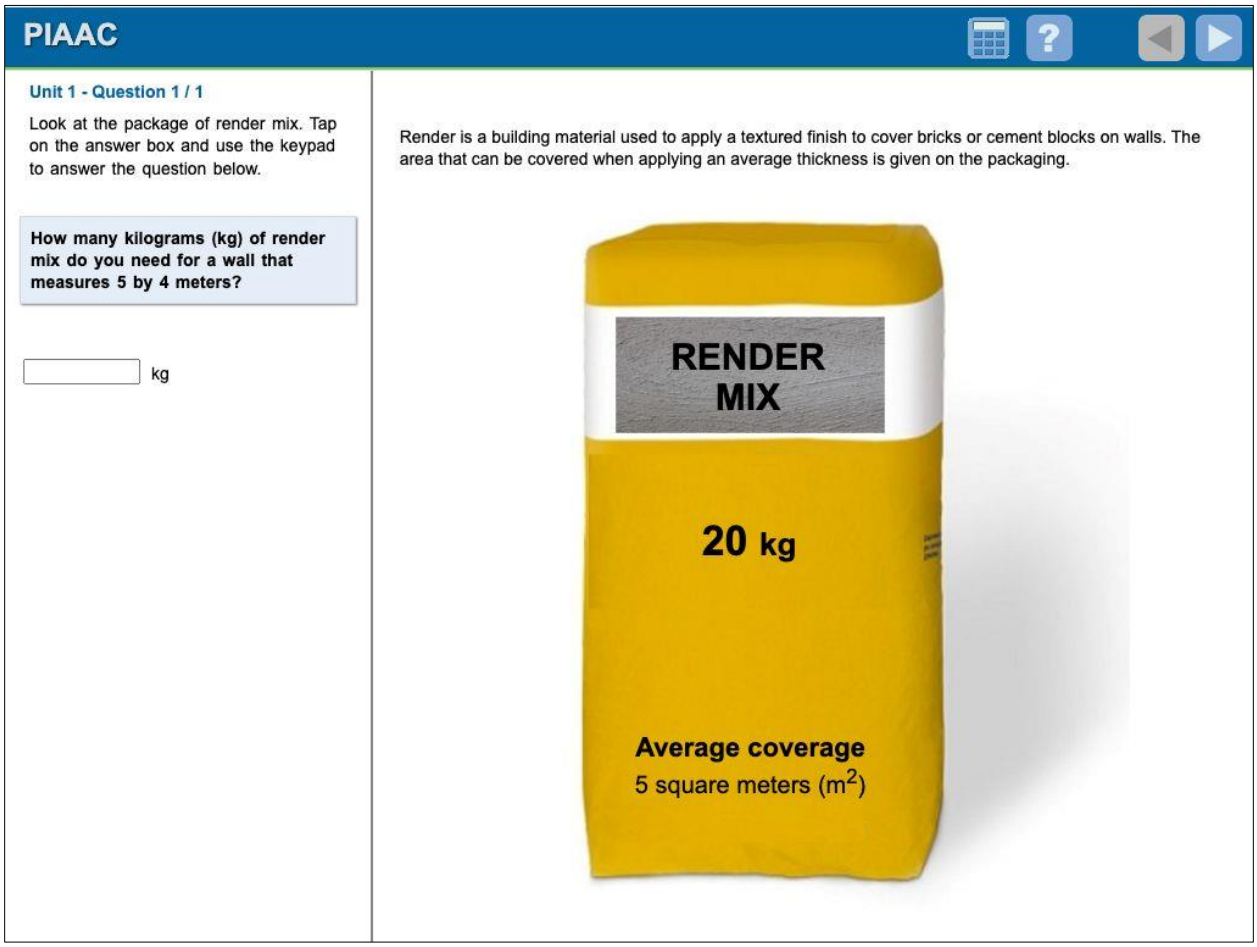
After the dynamic practice, respondents are informed that they have completed the practice and the first set of articles begins. The two images below are of one article, *A Letter to the Editor*, and the correct words have once again been selected. Even though this is a short article, it contains content relevant to an adult's life and could happen in many different communities. The format is also probably familiar to respondents as letters to the editor or opinion pieces are common in a wide variety of news forums.


PIAAC
Letter to the Editor – Page 1
Read the article as it displays on the screen.
When you come to a sentence where two words have been underlined, tap on the one word that makes the sentence make sense.
A Letter to the Editor
To the editor: Yesterday, it was announced that the cost of riding the bus will increase. The price will go up by twenty percent starting next wife / month. As someone who rides the bus every day, I am upset by this foot / increase. I understand that the cost of gasoline / student has risen. I also understand that riders have to pay a fair price / snake for bus service. I am willing to pay a little more because I rely on the bus to get to object / work. But an increase / uncle of twenty percent is too much.
Tap on the NEXT arrow to save your answers and continue.


PIAAC
Letter to the Editor – Page 2
Read the article as it displays on the screen.
When you come to a sentence where two words have been underlined, tap on the one word that makes the sentence make sense.
A Letter to the Editor
This increase is especially difficult to accept when you see the city's plans to build a new sports stadium. The government will spend millions on this project even though we already have a science / stadium. If we delay the stadium, some of that money can be used to offset the increase in bus fares / views. Then, in a few years, we can decide if we really do need a new sports cloth / arena. Please let the city council know you care about this issue by attending the next public meeting / frames.
You have completed the article. Tap on the NEXT arrow to save your answers and continue to the next section.

Section 5: Numeracy Items

Unit 817 – Render Mix



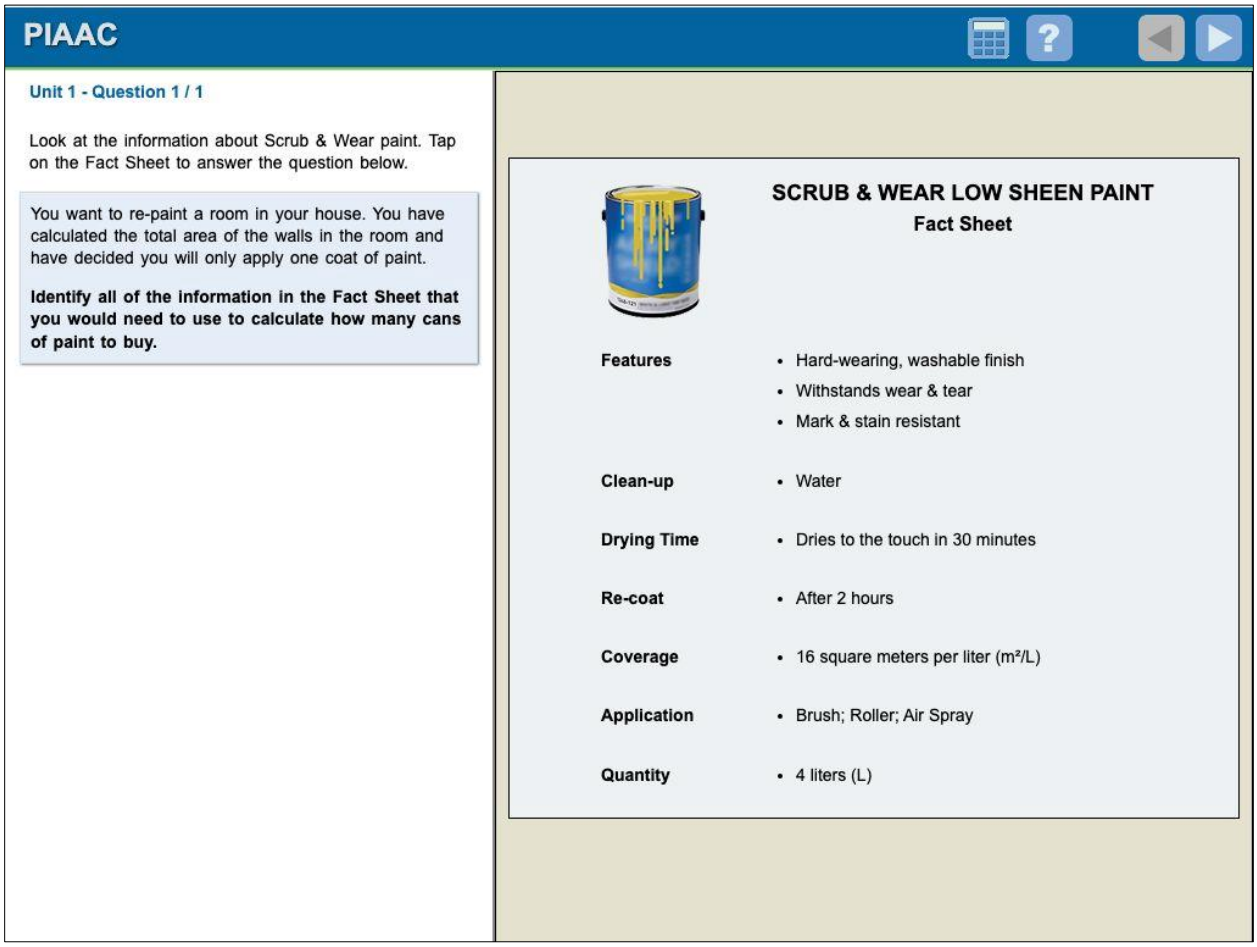
This is the unit *Render Mix*. In the stimulus, respondents are told that Render is a building material that adds a textured finish to brick or cement walls. They are also shown an image of a bag of the mix, which contains information on the label about the mass of one bag (20 kg) and the average surface area that one bag of mix can cover (5 m^2), when applied with uniform thickness.

For this task, respondents have to determine how many kilogrammes of mix are needed to cover a wall that measures 5 by 4 metres. This problem can be solved using proportional reasoning based on the surface area of the wall that needs to be covered, and the information about coverage on the label. That is, the wall to be covered measures 5 by 4 metres, which is 20 m^2, and the label states that 20 kg of mix can cover 5 m^2, so how many kilogrammes will cover 20 m^2? Since the area of the wall that needs to be covered is four times greater than the area that one bag of mix can cover, then the amount of mix needed must also be four times greater, so the correct answer is 80 kg. There was also a version developed using Imperial units for countries that use Imperial measurements as their standard. In the Imperial version, the bag weighs 20 pounds, covers an area of 10 ft^2, and the wall measures 10 by 10 feet. Both correct answers are shown in the table below.

The mathematical process assessed by this item is *act on and use mathematics* since the solution requires applying two routine algorithms – computing surface area and solving a simple proportion. The format of this item is "numeric entry", as respondents have to type the answer in the form of a number. This was a moderately difficult item, classified at Level 3 on the PIAAC Numeracy proficiency scale. There was no partial credit for this item.

Unit Name – Item #	**Render Mix – Item 1**	
Process	Act on and use mathematics	
Content Area	Space and shape	
Representation	Images of physical objects	
Context	Work	
Item Format	Numeric entry	
Answers	Metric 80	Imperial 200
Proficiency Level	3	

Unit 818 – Paint

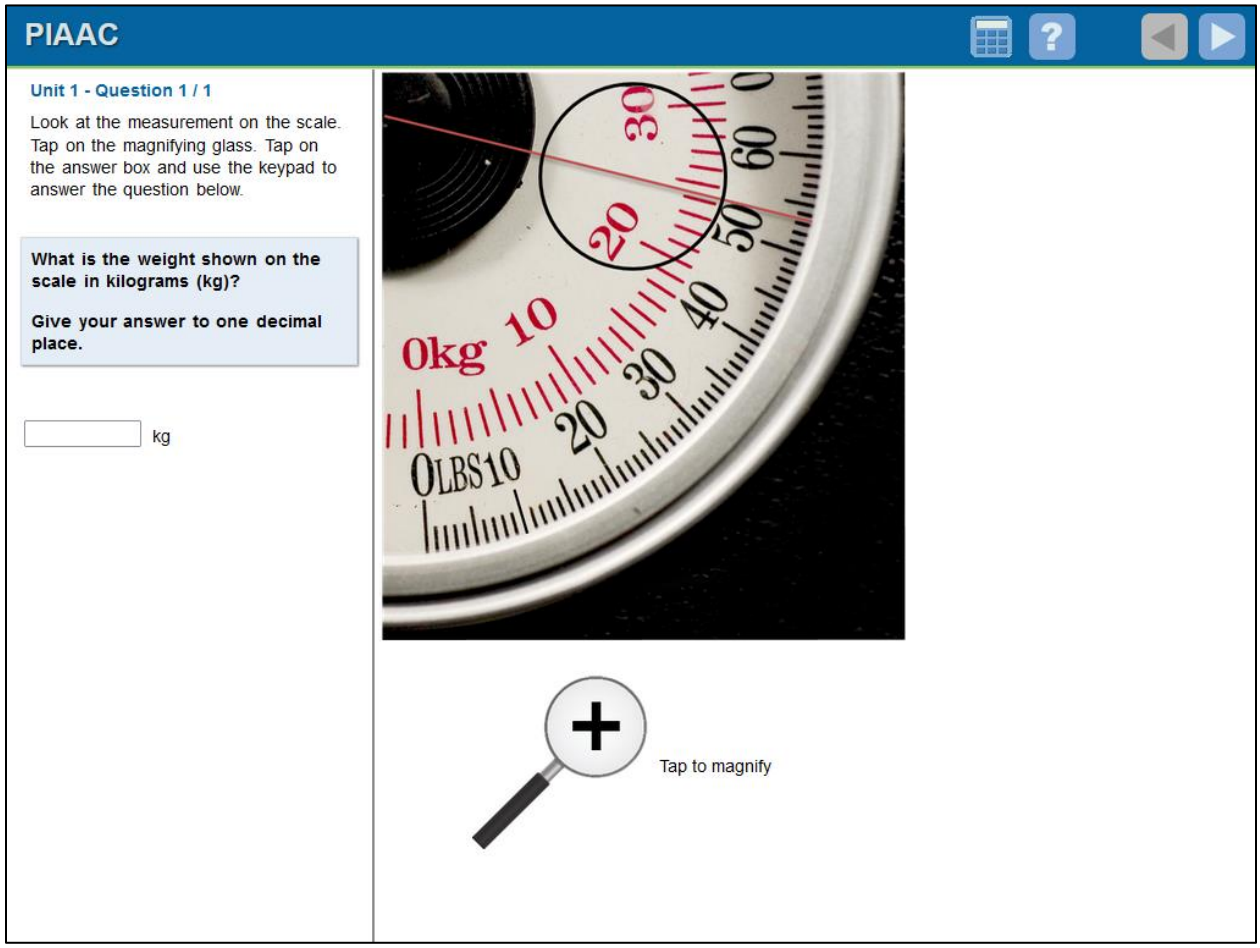


This is the unit *Paint*. For this item, the respondent is presented with a scenario of painting the walls of a room in a house. The stimulus shows a fact sheet that contains information about various attributes for a particular brand of paint. The task is to select (by tapping on the text in the fact sheet) only the pieces of information that are needed to determine how many cans of paint to purchase. Of the information presented on the fact sheet, Coverage (i.e., the area that one litre of paint can cover), and Quantity (i.e., the amount of paint in one can) are the only pieces of information needed for determining how many cans of paint to purchase. There was also a version developed using Imperial units for countries that use Imperial measurements as their standard. In the Imperial version, the coverage is 400 ft^2/gal, and the quantity is 1 gallon.

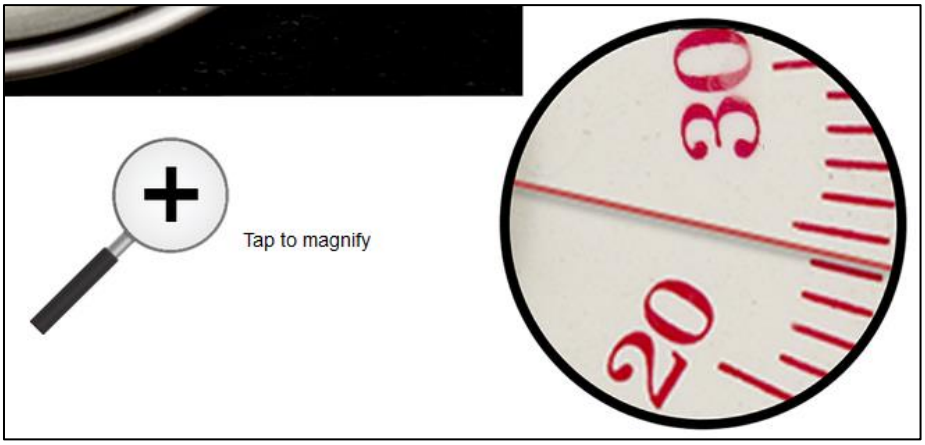
The mathematical process assessed by this item is *access and assess situations mathematically* because the task only requires identifying the essential information from the fact sheet that could be utilised to solve this specific problem. That is, the solution to this problem requires identifying the information needed but does not involve using that information to actually compute the number of cans of paint. A full-credit response required selecting only the two relevant pieces of information. There was no partial credit for correctly identifying one piece of information, and if any unnecessary pieces of information were selected, then the response was scored as incorrect. The format of this item is "tap on stimulus", as respondents have to tap on the relevant information in the fact sheet to respond. This was a moderately difficult item, classified at Level 3 on the PIAAC Numeracy proficiency scale.

Unit Name – Item #	**Paint – Item 1**
Process	Access and assess situations mathematically
Content Area	Space and shape
Representation	Structured information
Context	Personal
Item Format	Tap on stimulus
Answers	Selects two rows only: Coverage and Quantity
Proficiency Level	3

Unit 822 – Scale



This is the unit *Scale*. The stimulus shows a partial image of a scale that can be read in either kilogrammes or pounds. The task is to determine the weight of whatever object is on the scale (no specific object is shown, nor described in the text). To assist with reading the scale, respondents can tap on the image of the magnifying glass, and a detailed image, such as the one shown below, will appear on the screen.

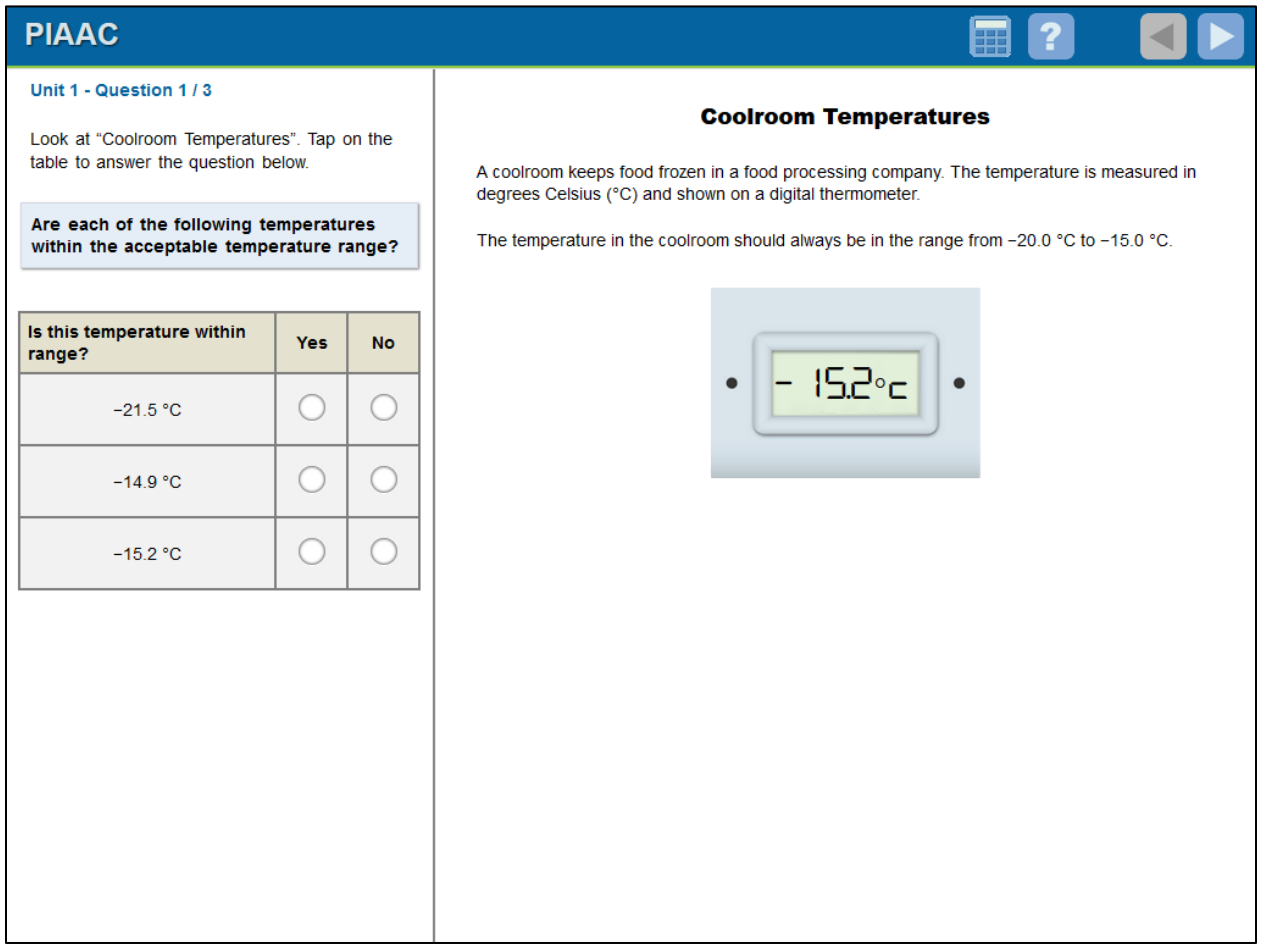


Metric and Imperial versions of the item were offered. However, regardless of the version, the weight is a non-integer quantity. In the Metric version, the weight of the object is between 24 and 25 kilogrammes, and in the Imperial version, the weight is between 53 and 54 pounds. This is a "numeric entry" item where respondents have to type in their answer, and they are told to give their answer to one decimal place. The full list of acceptable responses is given in the table below, and these were the only accepted responses. Note that regardless of the version, an acceptable response could not be an integer value, and it had to be below the mid-point of the two weights it is between (i.e., $24 < x < 24.5$ or $53 < x < 53.5$).

The mathematical process assessed by this item is *access and assess situations mathematically* because it requires interpreting a scale. Further, since the gradations on the scale are only for integer values, and the weight is a non-integer amount, there is an additional step of having to estimate the weight because it cannot be read directly. This item was moderately difficult and scaled at Level 3 on the PIAAC Numeracy proficiency scale.

Unit Name – Item #	**Scale – Item 1**	
Process	Access and assess situations mathematically	
Content Area	Space and shape	
Representation	Images of physical objects	
Context	Work	
Item Format	Numeric entry	
Answers	<u>Metric</u> 24.1 or 24,1 24.2 or 24,2 24.3 or 24,3 24.4 or 24,4	<u>Imperial</u> 53.1 or 53,1 53.2 or 53,2 53.3 or 53,3 53.4 or 53,4
Proficiency Level	3	

Unit 826 – Tolerances – Item 1

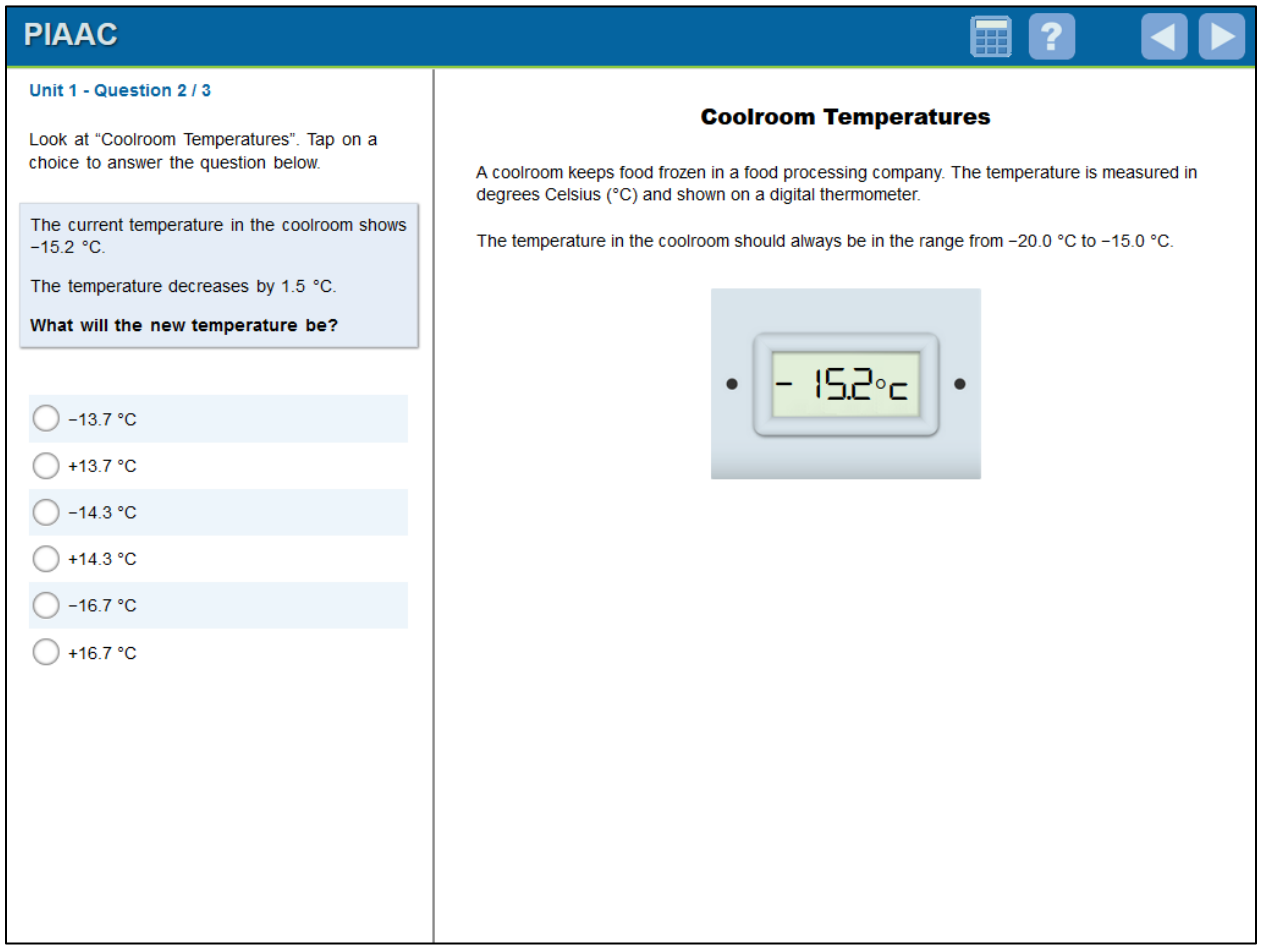


This is the first item in the unit *Tolerances*. For this item, respondents are presented with a scenario about a coolroom – a room that keeps foods frozen at a food processing company – which must maintain a temperature within the range of -20 °C to -15 °C. An Imperial version was not developed for the items in this unit. For the actual question, respondents are given a table of different temperatures and asked to identify whether or not each temperature is within the acceptable range. Responses are given by selecting either Yes or No for each temperature. The first temperature given in the table, -21.5 °C, is below the acceptable temperature range, so the correct selection is No. The next temperature, -14.9 °C, is above the acceptable temperature range, so the correct selection is again No. The final temperature, -15.2 °C, is within the acceptable temperature range, so the correct selection is Yes.

The mathematical process assessed by this item is *access and assess situations mathematically* because it requires identifying if particular values are within a specified range. Adding to the complexity of this item is that all the values are negative, and the temperatures listed in the table are all non-integers. However, this item was not overly difficult and scaled at Level 2 on the PIAAC Numeracy proficiency scale, which may have been a result of the item not requiring respondents to perform any computations; they only had to determine if each number was within the given temperature range. A full-credit response required correctly responding to each row in the table. There was no partial credit for this item.

Unit Name – Item #	**Tolerances – Item 1**
Process	Access and assess situations mathematically
Content Area	Space and shape
Representation	Images of physical objects
Context	Work
Item Format	Complex multiple choice
Answers	All three rows correct (from top to bottom): No, No, Yes
Proficiency Level	2

Unit 826 – Tolerances – Item 2

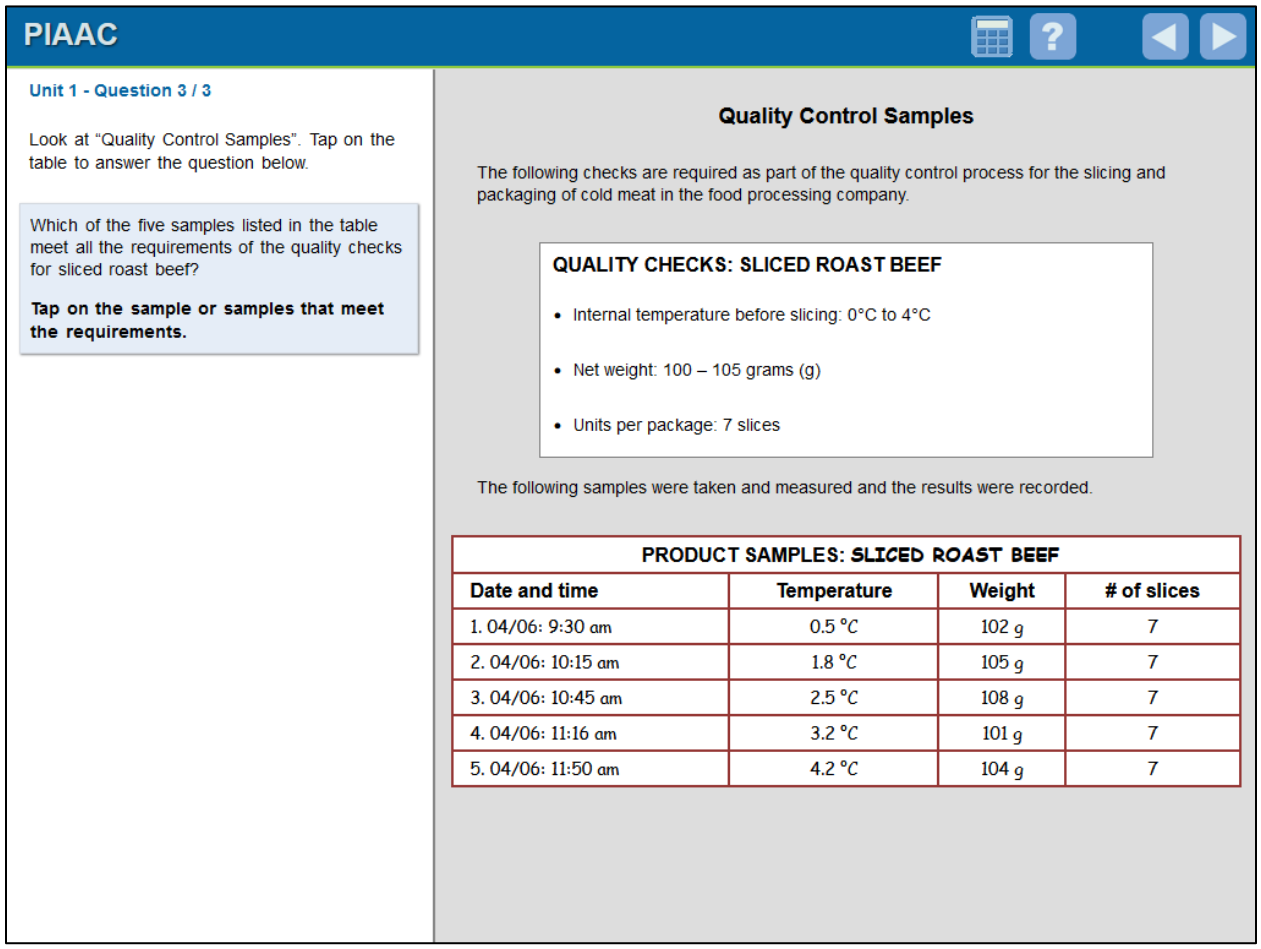


This is the second item in the unit *Tolerances*. Again, the situation is the coolroom that must maintain a temperature within the range of -20 °C to -15 °C. For this item, respondents are told that the current temperature in the room is -15.2 °C, but then the temperature in the room decreases by 1.5 °C so they need to determine the new temperature.

The mathematical process assessed by this item is *act on and use mathematics*. Respondents have to first interpret the situation to set up an arithmetic problem that they can solve. They have to recognise that a decrease implies subtraction, and then they have to subtract from a negative quantity (i.e., -15.2 – 1.5). The correct response is -16.7. A distractor of 16.7 is also included for consistency, as all the other options present the same absolute value but with differing signs due to common mistakes made when subtracting with negative numbers and the sign of the resulting difference. The value 13.7 comes from subtracting 1.5 from 15.2. The value 14.3 comes from the mistake of always subtracting a smaller number from a larger number. That is, respondents using this strategy subtract 1 from 15 to get 14 and .2 from .5 to get .3, leading to the value 14.3. This item was moderately difficult and scaled at Level 3 on the PIAAC Numeracy proficiency scale.

Unit Name – Item #	Tolerances – Item 2
Process	Act on and use mathematics
Content Area	Space and shape
Representation	Text or symbols
Context	Work
Item Format	Single selection multiple choice
Answer	5^{th} option: –16.7 ºC
Proficiency Level	3

Unit 826 – Tolerances – Item 3

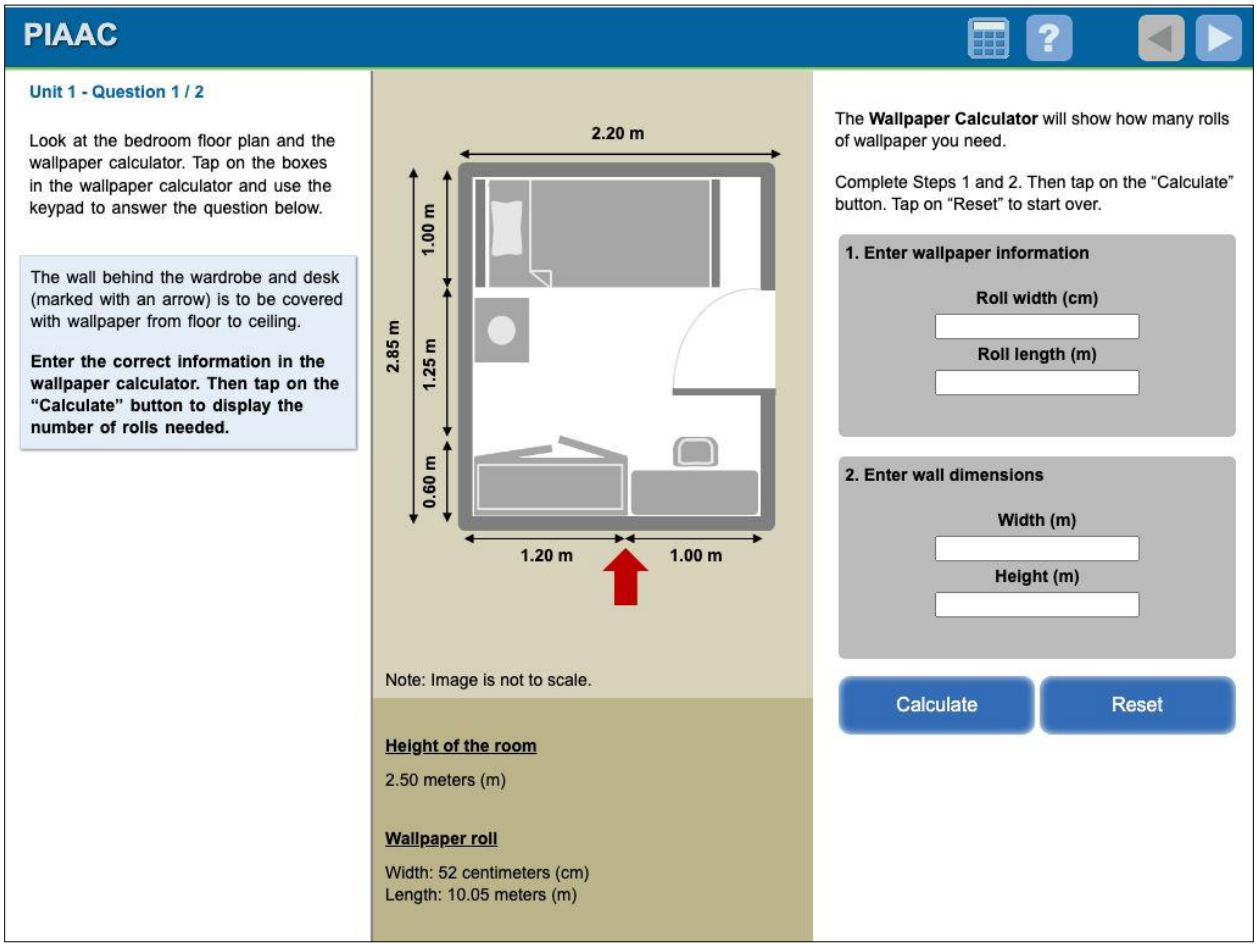


This is the final item in the unit *Tolerances*. With this item, the situation changes from monitoring the temperature in the coolroom to reviewing quality checks performed on one of the products – packages of sliced roast beef – prepared by the company. The stimulus shows a list of three quality checks that the company performs, which includes checking the internal temperature, in degrees Celsius, before slicing; the net weight, in grams, of the slices; and the total number of slices per package. Below that list is a table, which shows the temperature, weight, and number of slices for five samples taken at various times throughout a day. The task for the respondent is to select the samples that meet the requirements of all three quality checks.

The mathematical process assessed by this item is *evaluate, critically reflect, and make judgments*. This item requires respondents to analyse samples to determine if the data for each sample are within the acceptable ranges. The correct answer is samples 1, 2, and 4. All five samples contain the appropriate number of slices (7), so they all pass on that criterion. Sample 3 has an acceptable temperature (2.5 °C) but does not pass because the net weight (108 g) is outside of the allowable range. Sample 5 has an acceptable weight (104 g) but does not pass because the temperature (4.2 °C) is outside of the allowable range. A full-credit response required correctly identifying all samples that met all three requirements. There was no partial credit for this item. The format of this item is "tap on stimulus", as respondents have to tap on the samples (by tapping anywhere in the row) to respond. This item was moderately difficult and scaled at Level 3 on the PIAAC Numeracy proficiency scale.

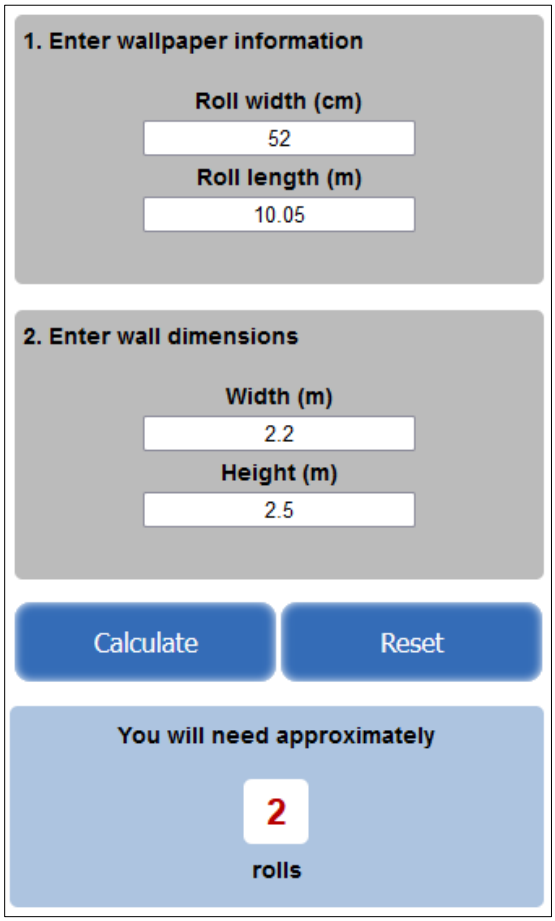
Unit Name – Item #	**Tolerances – Item 3**
Process	Evaluate, critically reflect, and make judgments
Content Area	Space and shape
Representation	Text or symbols
Context	Work
Item Format	Tap on stimulus
Answers	All three selections correct: Samples 1, 2, and 4
Proficiency Level	3

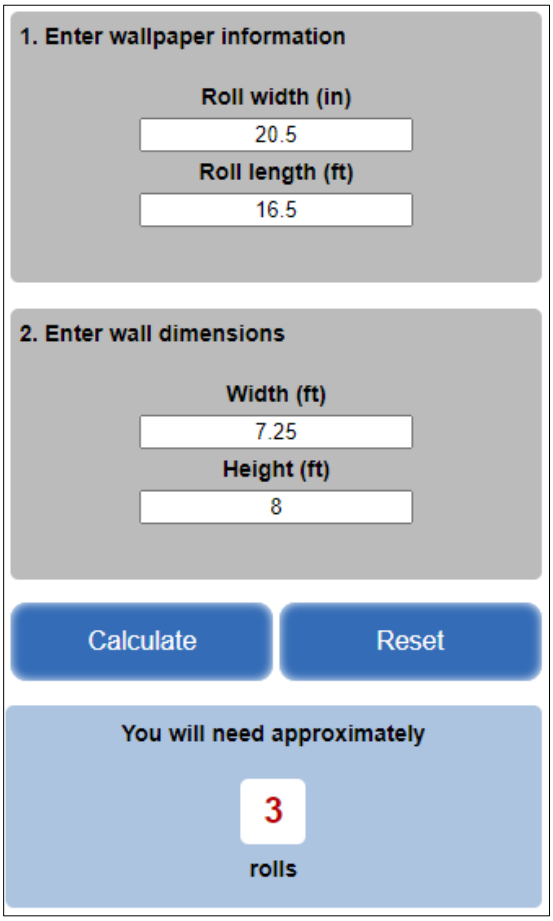
Unit 829 – Wallpaper – Item 1



This is the first item in the unit *Wallpaper*. In this item, respondents are presented with a situation in which a wall needs to be completely covered in wallpaper. A "wallpaper calculator" is provided to assist with determining the number of rolls of wallpaper needed for the project. The wallpaper calculator determines the number of rolls by using the following four inputs: the roll width, in centimetres; the roll length, in metres; the width of the wall, in metres; and the height of the wall, in metres. There is also a stimulus that contains a diagram of the room with the length and width of the walls marked. The height of the room and the dimensions of the wallpaper roll are listed below the diagram of the room. There was also a version developed using Imperial units for countries that use Imperial measurements as their standard. In the Imperial version, the wallpaper roll width is 20.5 inches, the roll length is 16.5 feet, the width of the wall is 7.25 feet, and the height of the wall is 8 feet.

The task is to use the wallpaper calculator to determine the number of rolls of wallpaper needed. Once the fields are all populated, the respondent can tap on “Calculate” to get the output. If respondents want to change the value in a particular cell, they can tap on that cell and use the “Backspace” button on the keypad to delete the current number. If respondents tap on “Reset,” it will clear all fields that are currently populated. Images of the calculator with the fields correctly populated and the output shown are given below for both the Metric and the Imperial version of this item.

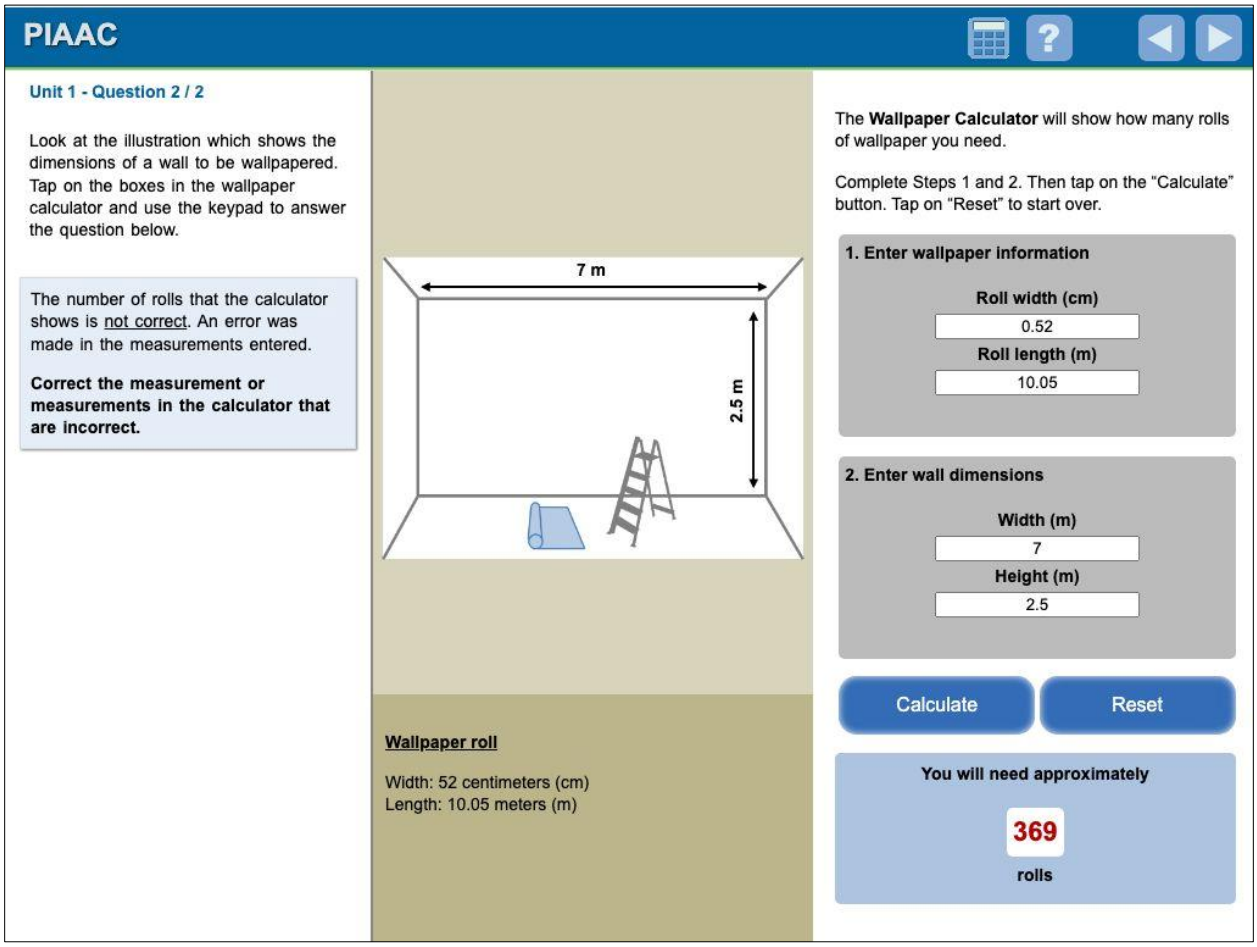




The mathematical process assessed by this item is *access and assess situations mathematically* because to use the wallpaper calculator, respondents have to first identify the relevant information from the diagram and stimulus, which contains excess information, and then match it to the appropriate fields in the calculator. A full-credit response required correctly populating all four fields. There was no partial credit for this item. The format of this item is “numeric entry”, as respondents have to type numerical values into the wallpaper calculator. This item was moderately difficult and scaled at Level 3 on the PIAAC Numeracy proficiency scale.

Unit Name – Item #	**Wallpaper – Item 1**	
Process	Access and assess situations mathematically	
Content Area	Space and shape	
Representation	Dynamic applications	
Context	Personal	
Item Format	Numeric entry	
Answers	<u>Metric</u> Roll width in cm: 52 Roll length in metres: 10.05 or 10,05 Width in metres: 2.2 or 2,2 Height in metres: 2.5 or 2,5	<u>Imperial</u> Roll width in inches: 20.5 or 20,5 Roll length in feet: 16.5 or 16,5 Width in feet: 7.25 or 7,25 Height in feet: 8
Proficiency Level	3	

Unit 829 – Wallpaper – Item 2



This is the second item in the unit *Wallpaper*, and in this item, a wall in a different room is going to be wallpapered. Once again, the stimulus shows a diagram of the room with the dimensions labelled, and the dimensions of the wallpaper roll are given. For this item, the wallpaper calculator has already been used to determine the number of rolls needed. However, an error was made with one or more values that were entered into the tool. The task is to identify the error(s) and enter the correct value(s).

Respondents have to compare each of the fields in the wallpaper calculator to the information shown in the stimulus to determine the incorrect field(s). In the Metric version, the incorrect field is "Roll width (cm)" and the error is that the value was entered as 0.52. Respondents need to delete 0.52 and replace it with 52. In the Imperial version, the incorrect field is "Roll length (ft)" and the error is that the value was entered as 1.65. Respondents need to delete 1.65 and replace it with 16.5. In each version there is only one incorrect field.

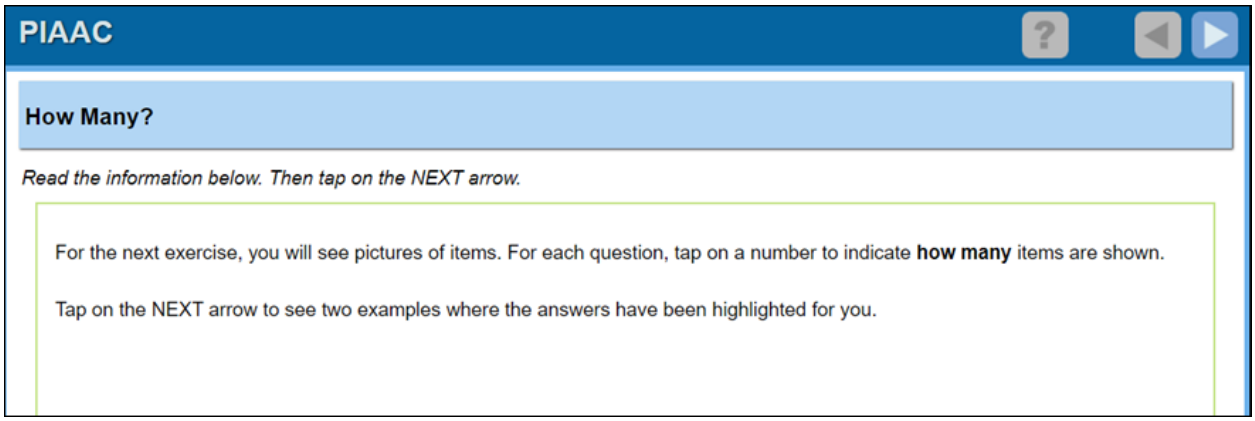
The mathematical process assessed by this item is *evaluate, critically reflect, and make judgments*. Respondents have to first identify the mistake that was made in order to make the necessary adjustment that will result in a more reasonable output for this situation. Again, the format of this item is "numeric entry", as respondents have to type a numerical value into the wallpaper calculator. This item was less difficult and scaled at Level 2 on the PIAAC Numeracy proficiency scale. There was no partial credit for this item.

Unit Name – Item #	**Wallpaper – Item 2**	
Process	Evaluate, critically reflect, and make judgments	
Content Area	Space and shape	
Representation	Dynamic applications	
Context	Personal	
Item Format	Numeric entry	
Answers	<u>Metric</u> Roll width changed to 52	<u>Imperial</u> Roll length changed to 16.5 or 16,5
Proficiency Level	2	

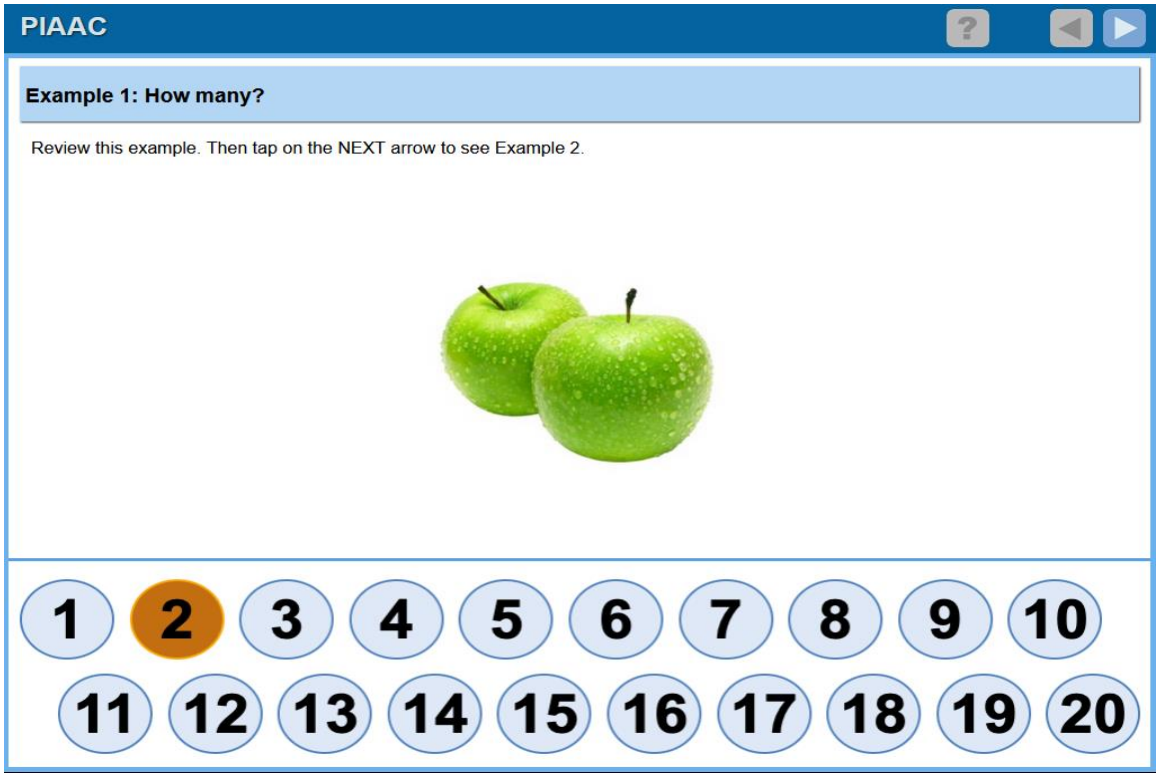
Section 6: Numeracy Components Items

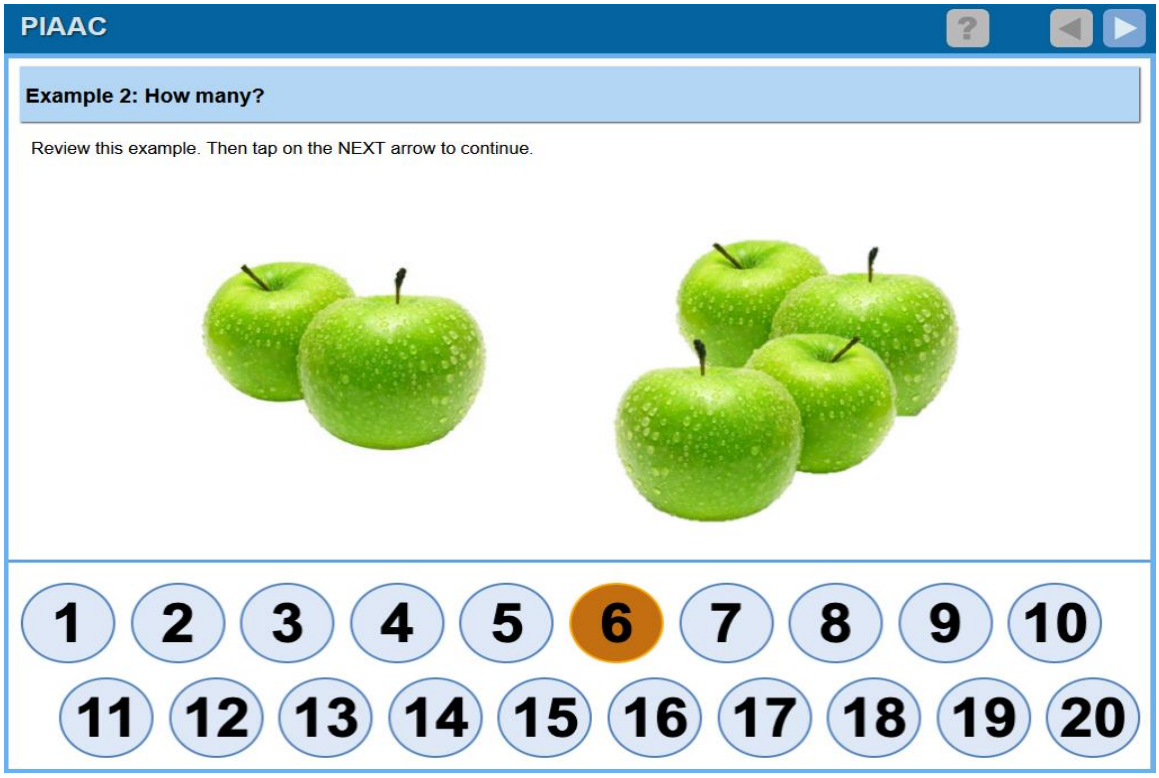
Numeracy Components in PIAAC Cycle 2 include two tasks – “How Many” and “The Biggest”. Both tasks are designed to measure a respondent’s fluency with number sense. Number sense relates to the sense of quantities and how numbers represent quantities and is a major component of Numeracy. Respondents with adequate Numeracy skills should be able to respond to each item quickly and accurately. Respondents with Numeracy skills characterised as “Below Level 1” or “Level 1” on the Numeracy proficiency scale may find some items more difficult. Performance on the Components tasks will be used along with performance on the Numeracy tasks to describe the Numeracy proficiency scale. These tasks will be particularly useful in describing the skills of adults at the lowest levels of the Numeracy scale.

How Many?

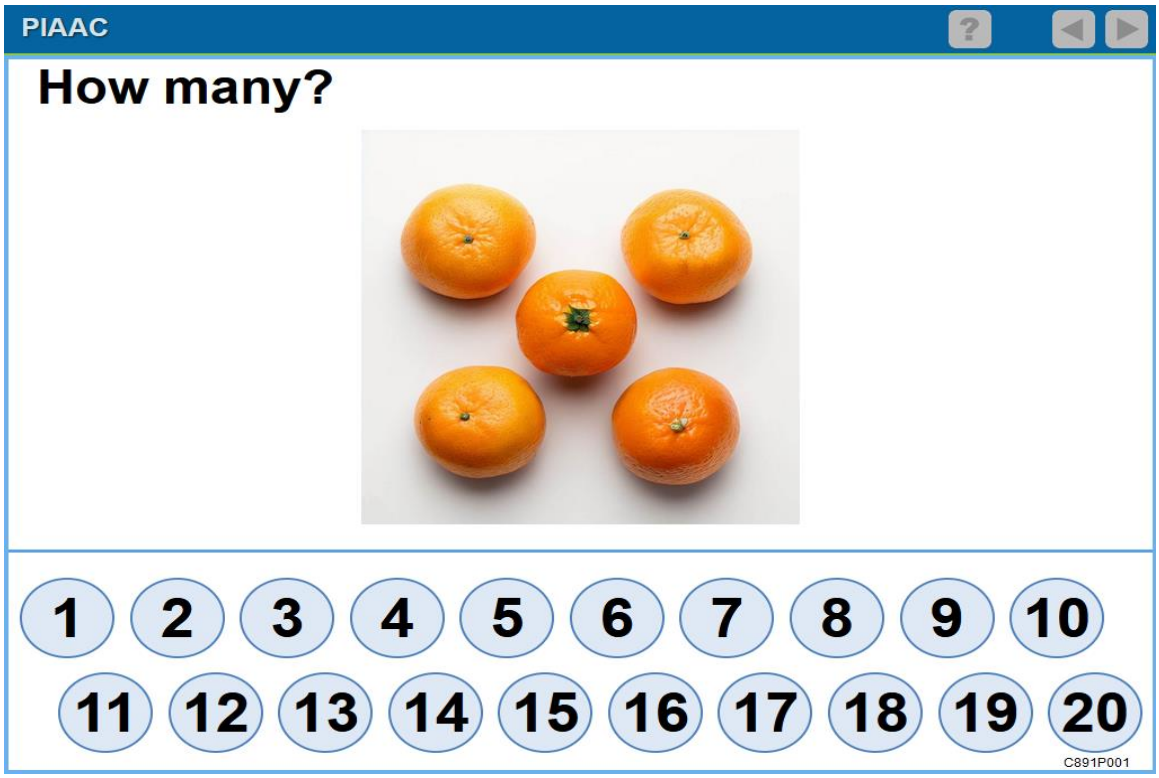


In this first task, How Many, images of similar items appear on the screen. Respondents are asked to indicate how many items are on the screen by tapping a number from 1 – 20. Images of two practice examples are shown below and have already been completed with the correct number selected.


PIAAC
Example 1: How many?
Review this example. Then tap on the NEXT arrow to see Example 2.
1 2 3 4 5 6 7 8 9 10
11 12 13 14 15 16 17 18 19 20


PIAAC
Example 2: How many?
Review this example. Then tap on the NEXT arrow to continue.
1 2 3 4 5 6 7 8 9 10
11 12 13 14 15 16 17 18 19 20

After the practice examples, respondents are informed that they have completed the practice and the first set of items begins. The set of four items shown below is a shorter version of the How Many task administered in PIAAC Cycle 2.



PIAAC

How many?

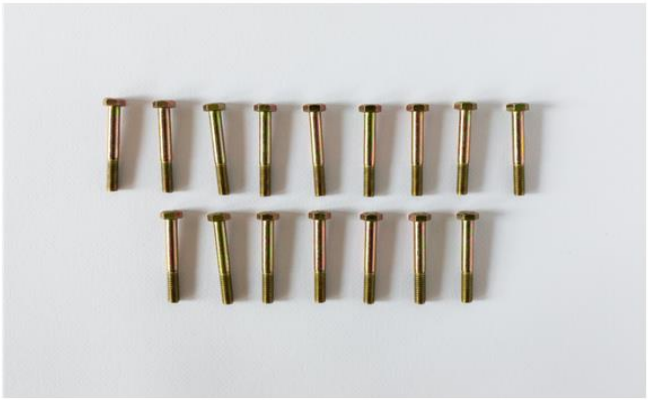
1 2 3 4 5 6 7 8 9 10

11 12 13 14 15 16 17 18 19 20

C891P002

PIAAC

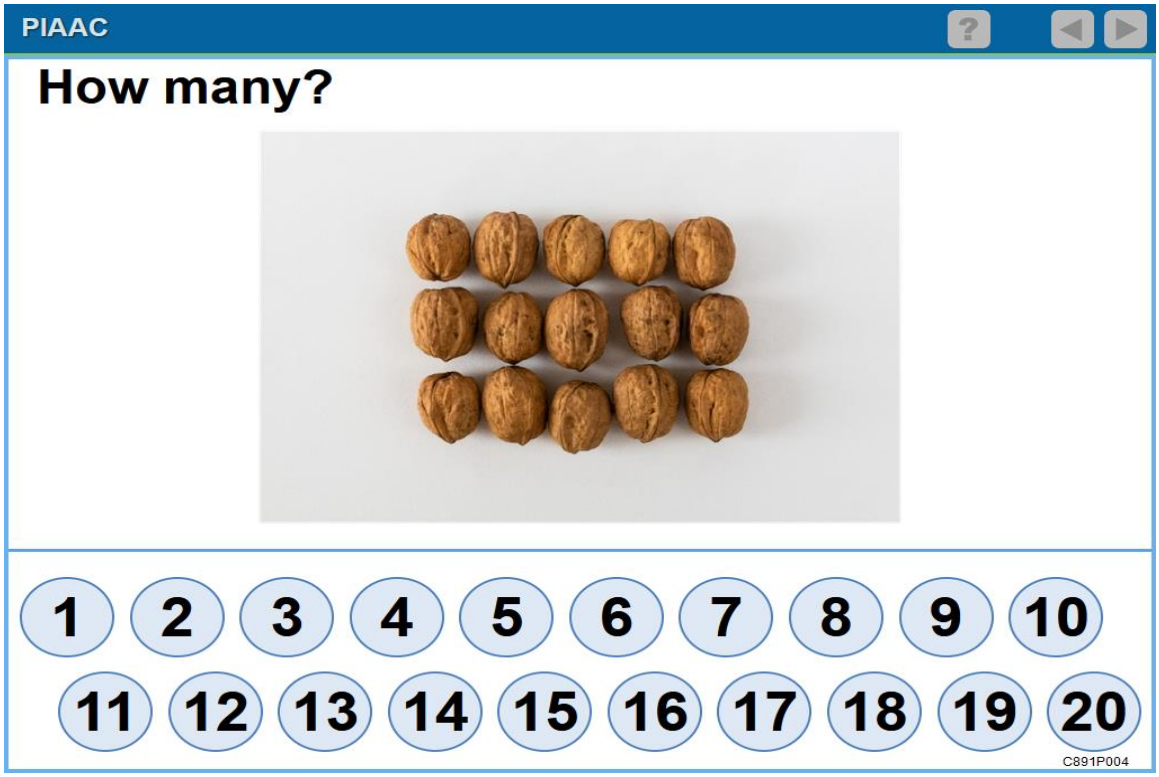
How many?



1 2 3 4 5 6 7 8 9 10

11 12 13 14 15 16 17 18 19 20

C891P003

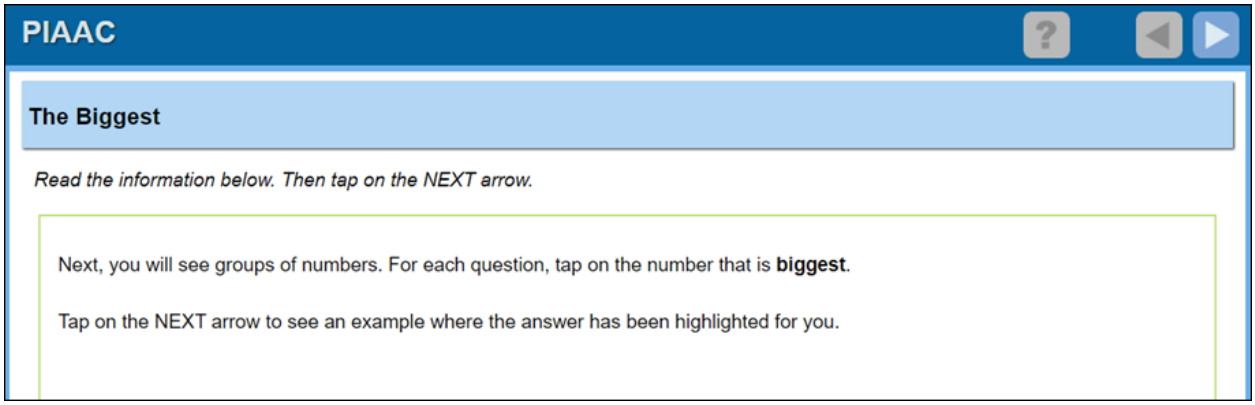


The object and the correct number are listed below for these four items.

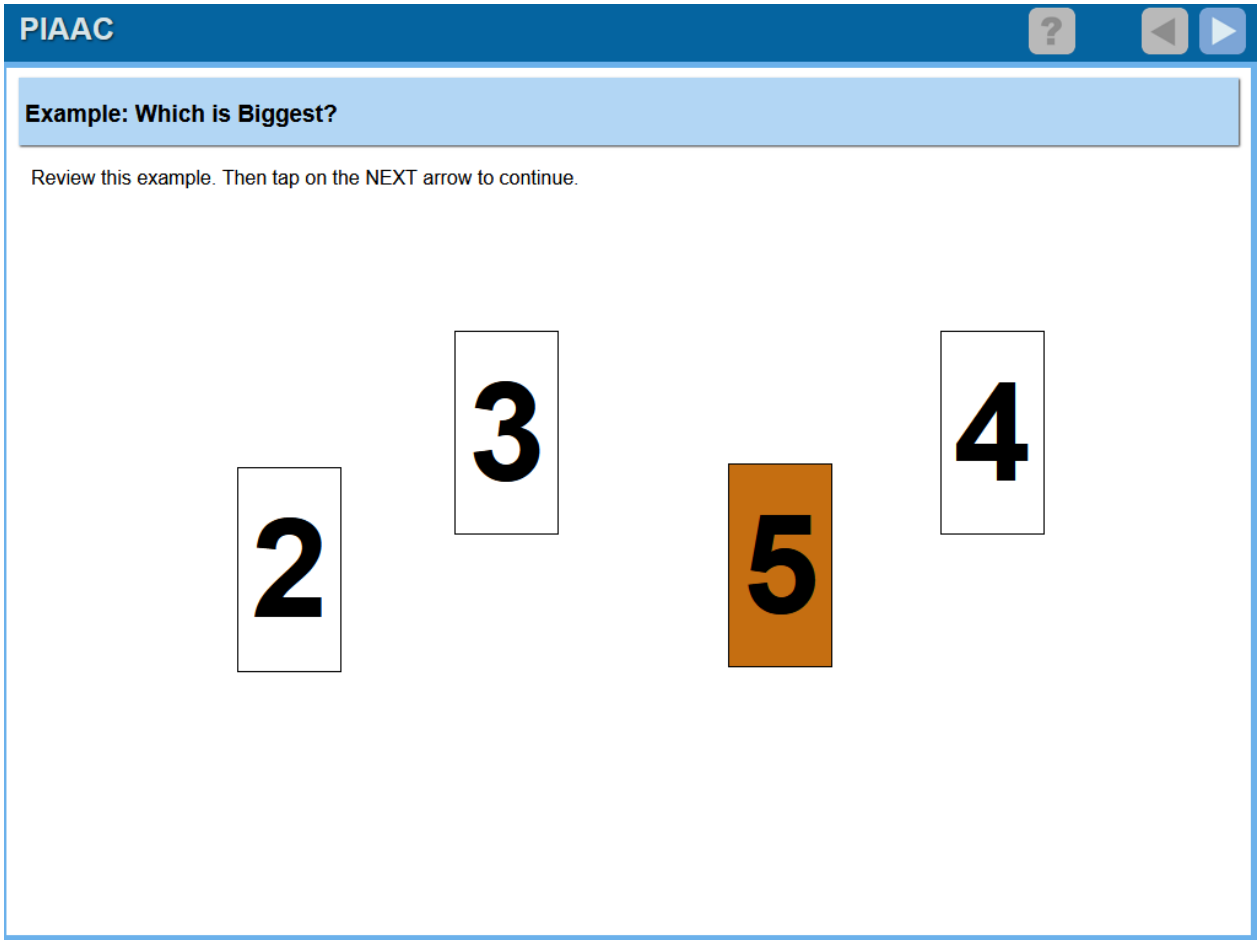
- Tangerines [5]
- Limes [6]
- Bolts [16]
- Walnuts [15]

Items with a small number of objects, such as tangerines or limes, can be responded to more quickly than items with a larger number of objects. However, for items with larger numbers of objects, the way they are grouped can make it easier to determine how many objects are in the picture. The bolts were grouped less efficiently than the walnuts which were organised in three rows of five. Respondents that can use that organisation to quickly multiply three and five can likely respond to this item more quickly than the item with bolts. The How Many task in PIAAC Cycle 2 included images of objects that varied in the ways shown in these examples.

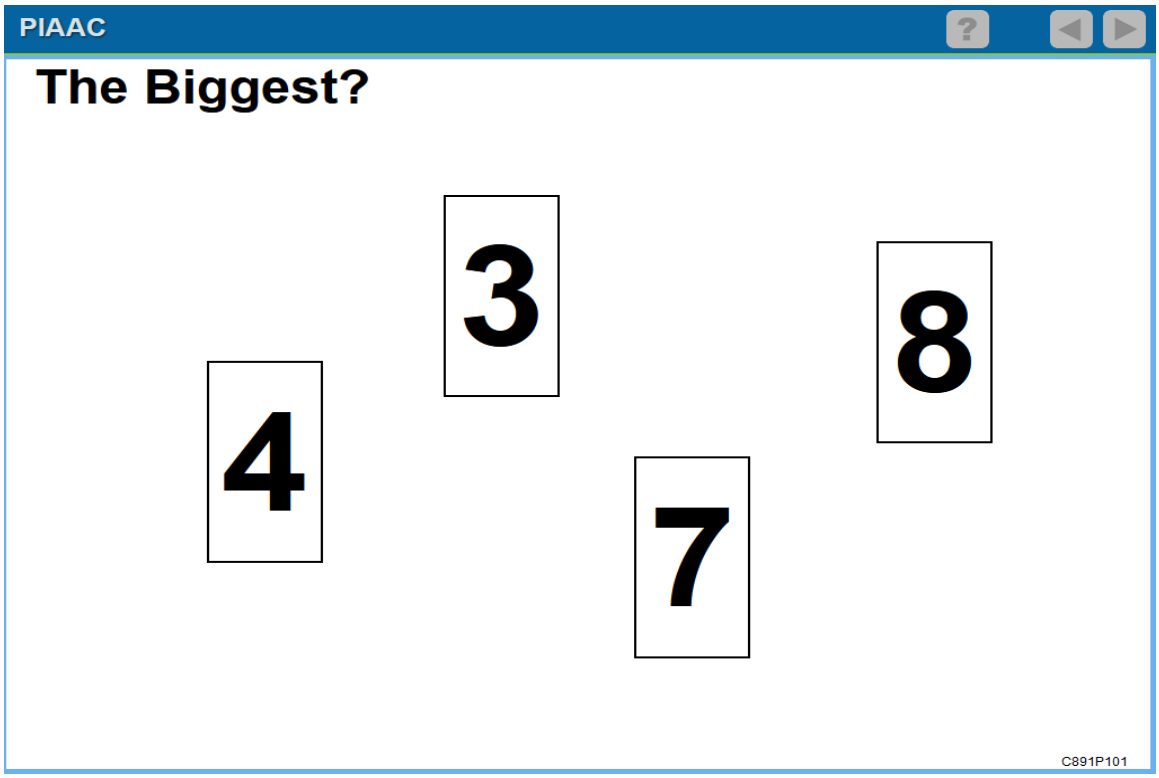
Which is Biggest?

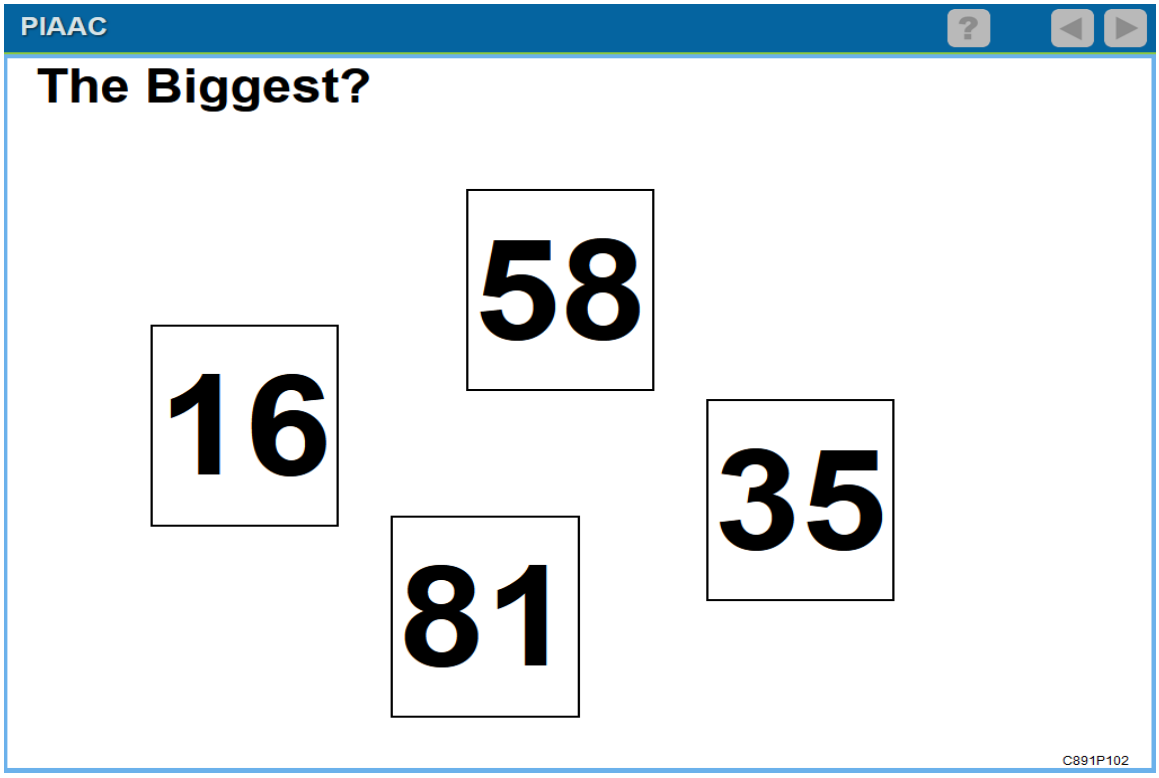


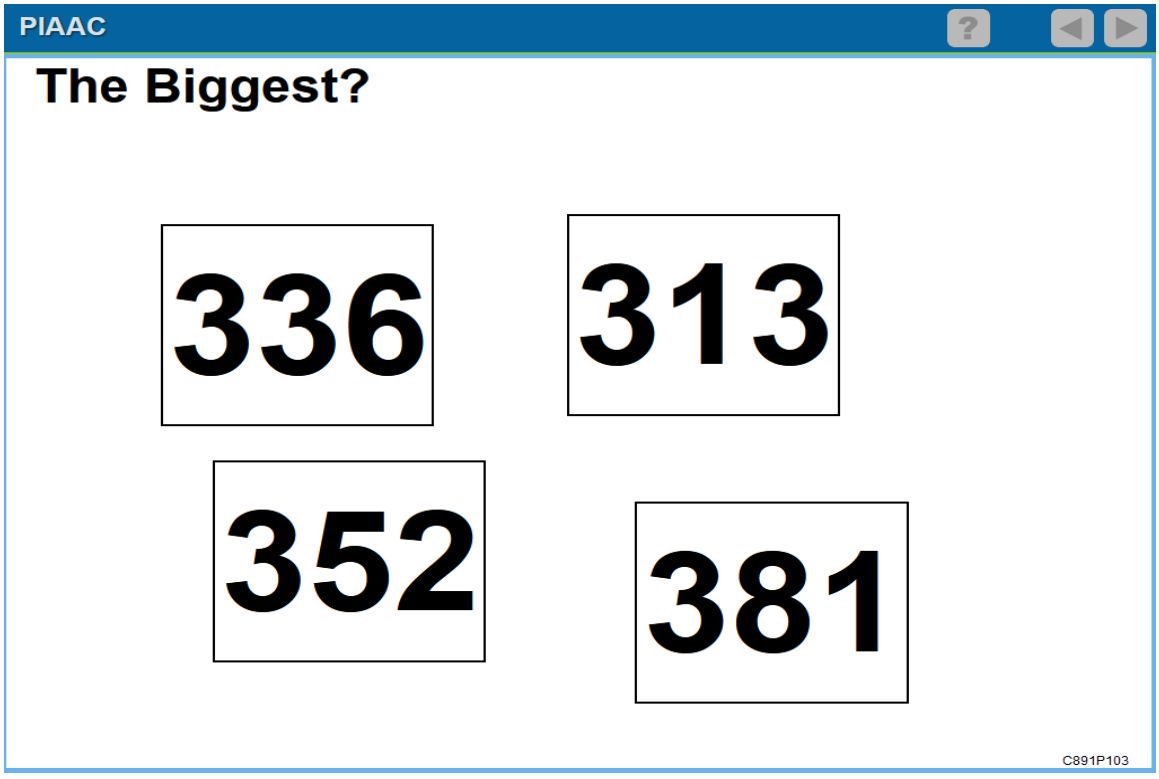
In The Biggest task, four numbers appear in each item. For each item, the respondent selects the number that is the biggest amongst the four numbers. One example item is shown below with the biggest number already selected.

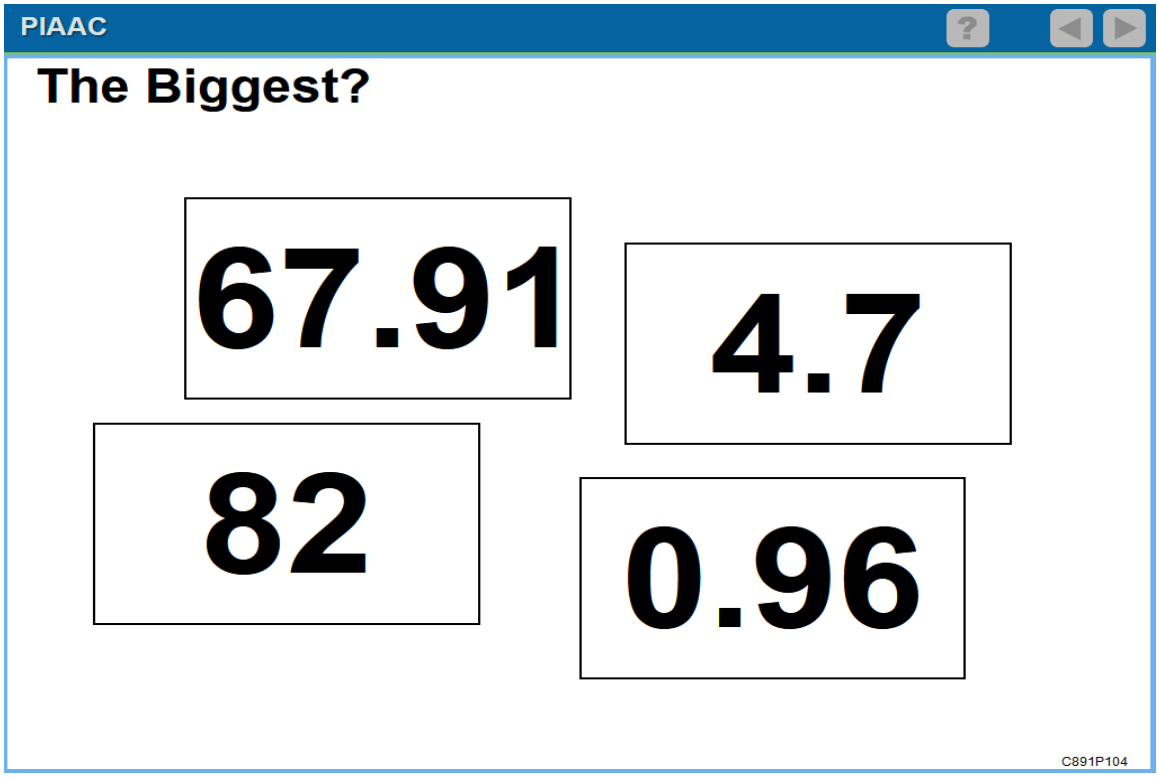


The set of four items shown below is a shorter version of The Biggest task administered in PIAAC Cycle 2.




PIAAC
The Biggest?
58
16
35
81
C891P102


PIAAC
The Biggest?
336
313
352
381
C891P103



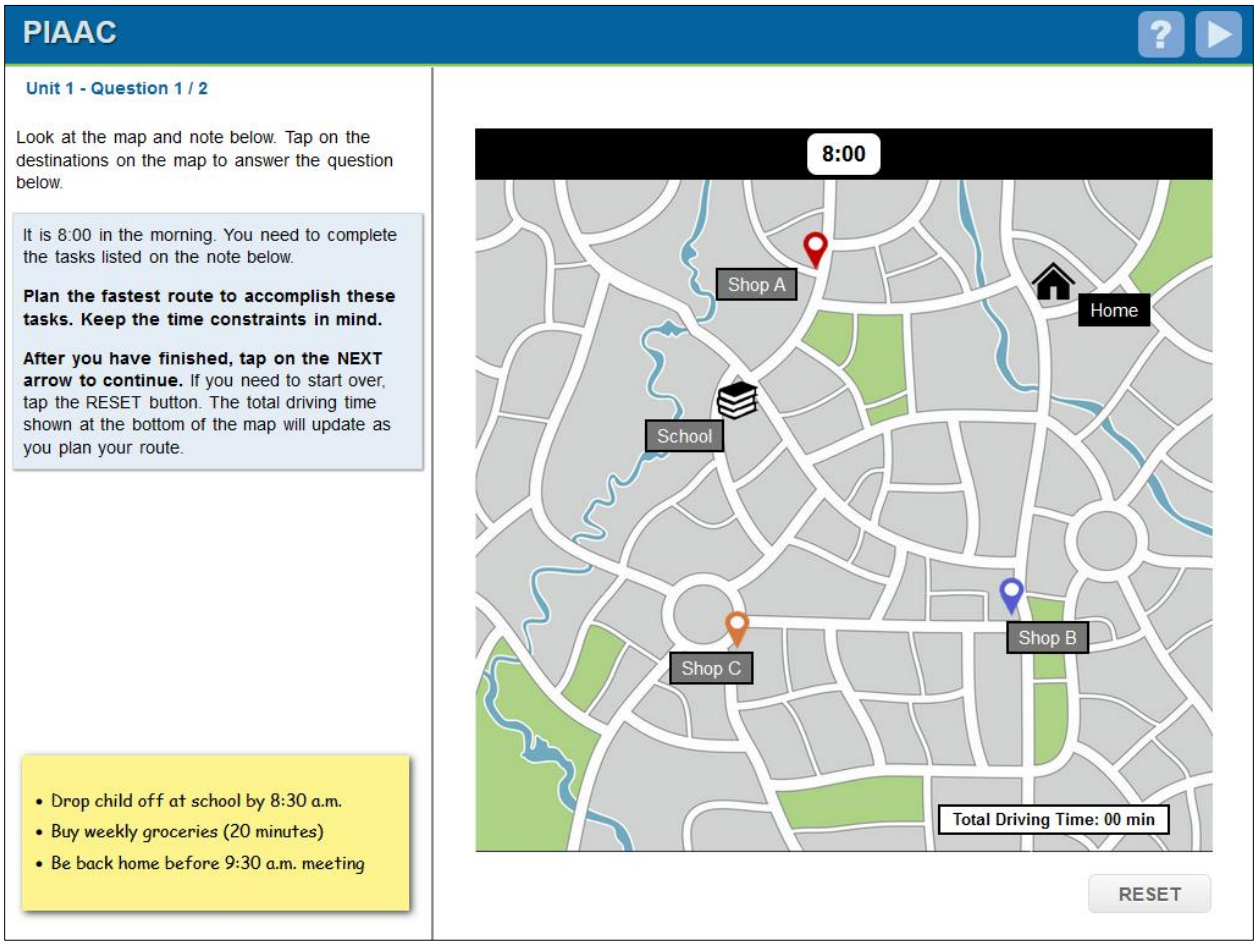
The correct answer is shown below in bold for each item. Note that the order from left to right that the numbers are listed below corresponds to the order in which they appeared on the screen.

- 4, 3, 7, **8**
- 16, 58, **81**, 35
- 336, 352, 313, **381**
- 67.91, **82**, 4.7, 0.96

The difficulty increased slightly across all four items, representing a range of difficulty similar to the full task respondents completed in the PIAAC assessment. The first three items should be very easy for most respondents as all values are whole numbers. The fourth item represents one of the more difficult items in this task because decimal numbers are also used. However, the values in the tenths and hundredths places can be ignored because the largest number is identified by the value in the tens place. Similar items have a difficulty of "Level 1", whereas items with only whole numbers are all "Below Level 1" on the Numeracy proficiency scale. Some respondents, particularly those with lower levels of numeracy skills, may not correctly answer items like the fourth item.

Section 7: Adaptive Problem-Solving Items

Unit 120 – Best Route – Item 1



This is the first item in the unit *Best Route*. This unit was originally titled "*Dinner Preparations*" and was developed as a conceptual example in the Adaptive Problem-Solving framework. Changes were made to optimize the functionality within the unit and to accurately represent the problem's constraints in a programmed version. In this item, respondents need to use an interactive map to find the fastest route to accomplish three tasks, keeping a set of time constraints in mind. Specifically, the person in the scenario needs to drive their child to school by 8:30 a.m., then drive to buy their weekly groceries, and finally drive home before 9:30 a.m. for a meeting. The interactive map shows a home, a school, and three shops. Times are determined by tapping on any of the marked locations on the map. When a location is tapped, a route is marked with a dashed line, and the total driving time is displayed in the lower right corner. To solve this problem, respondents will need to explore different routes and collect information on the total driving time. Their response only becomes final once they tap on the arrow to advance to the second item and are asked to confirm their answer.

Respondents are told that the current time is 8:00 a.m. and that the first task on the list is to drop their child off at school by 8:30 a.m., so all acceptable routes must begin by driving from home to the school, a trip that takes 25 minutes. After that, the respondent needs to explore the different driving times between the school and each shop, and the driving time between each shop and home, while also keeping in mind the 20 minutes that will be spent at the shop. The table below shows each possible route in the order that it needs to be driven, as well as the total driving time, the shopping time, and the time the person would return home after completing each task on the list.

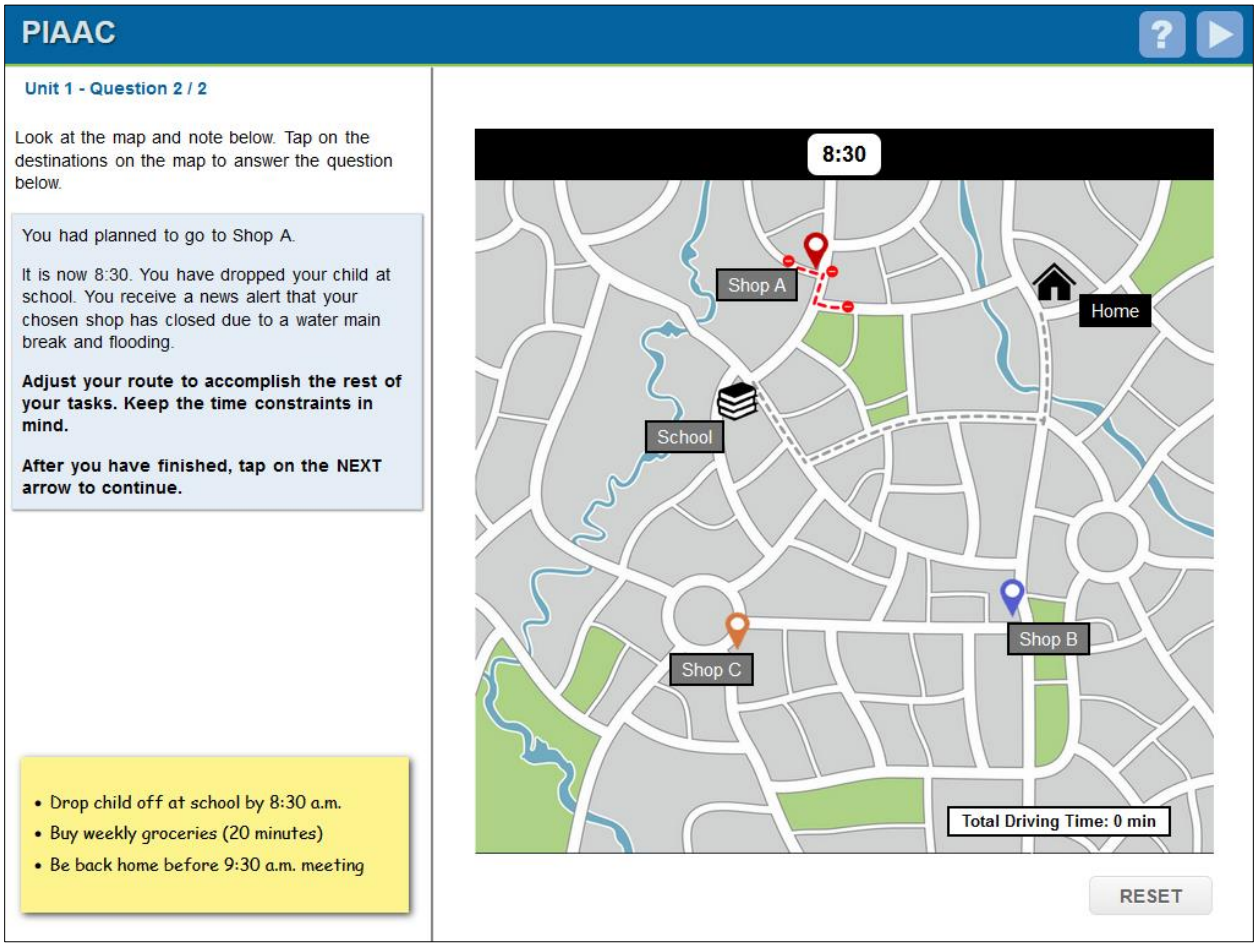
Routes	**Total Driving Time**	**Shopping Time**	**Return Home**
Home → School → Shop A → Home	50 min.	20 min.	9:10 a.m.
Home → School → Shop B → Home	60 min.	20 min.	9:20 a.m.
Home → School → Shop C → Home	75 min.	20 min.	9:35 a.m.

Going to Shop C does not work because the person returns home after 9:30 a.m. If the person were to go shopping at either Shop A or Shop B, they would be able to return home in time for their 9:30 meeting. However, the question specifically asks for the fastest route, so the correct answer is to plan a route based on driving to Shop A after dropping their child off at school (i.e., Home → School → Shop A → Home).

The cognitive and metacognitive process classifications for this item are *Searching for a solution: Searching for operators in the problem environment* and *Searching fora solution: Evaluating operators/plans*, respectively, since the crux of this problem involves analysing all the possible routes, given the order that the tasks need to occur and the time constraints, to determine which route achieves the desired outcome (i.e., the fastest route to accomplish all tasks and have the person home before 9:30 a.m.). The information environment for this item is *physical resources* because this problem is one that in a real-life scenario would be solved by choosing the shop that is closest, in terms of driving time, to each location (i.e., driving time between the school and the shop, and then between the shop and home). This item was developed to be of low to moderate difficulty. This is due to the limited amount of information respondents have to consider (route and driving times are the only operators), and to the limited number of decisions they have to make (e.g., all routes and drive times are predefined and do not change), in order to solve this problem.

Unit Name – Item #	**Best Route – Item 1**
Cognitive Process	Searching for solution: Searching for operators in the problem environment
Metacognitive Process	Searching for solution: Evaluating operators/plans
Problem Context	Personal
Information Environment	Physical resources
Item Format	Tap on stimulus
Answers	Taps on the following locations (in this order): 1) School 2) Shop A 3) Home
Estimated Difficulty	Low to moderate

Unit 120 – Best Route – Item 2



This is the second item in the unit *Best Route*. In this item, respondents encounter an impasse – flooding caused by a water-main break makes Shop A inaccessible – so the original plan to go to Shop A is no longer feasible, and a different route must be chosen while still keeping in mind the task list and time constraints. The alert about the water-main break happens right after the child has been dropped off at school, so for this item the current time is 8:30 a.m. and the School is used as the starting location for determining how to adjust the route.

The updated table below shows the two possible routes based on going to Shop B or Shop C, including the order that they need to be driven, the total driving time, the shopping time, and the time at which the person would return home after completing the remaining tasks on the list. Of the two possible routes, the only one that will work is to go to Shop B, and once again, going to Shop C does not work because the person returns home after 9:30 a.m.

Routes	Total Driving Time	Shopping Time	Return Home
School → Shop B → Home	35 min.	20 min.	9:25 a.m.
School → Shop C → Home	50 min.	20 min.	9:40 a.m.

The cognitive process classification of this item is *Searching for a solution: Searching for operators in the problem environment* since the crux of this problem still involves analysing possible routes that will achieve the desired outcome (i.e., the route that allows the person to complete their shopping and still make it home before 9:30 a.m.). The metacognitive process measured by this item is *Applying a solution: Monitoring/regulating progress* since the solution needs to be modified as the problem changes. The information environment for this item is, again, *physical resources* because the problem would be solved in a real-life, physical scenario. This item was also developed to be of low to moderate difficulty because the change – i.e., the adaptation to the problem introduced in this item – is relatively minor. The number of decisions the respondent must make is reduced because there is one fewer route to analyse, and only one of them allows for returning home in time for the 9:30 a.m. meeting. Thus, while respondents have to make adjustments to their original plan, on balance, the item difficulty is likely to be similar to the first item.

Unit Name – Item #	**Best Route – Item 2**
Cognitive Process	Searching for solution: Searching for operators in the problem environment
Metacognitive Process	Applying a solution: Monitoring/regulating progress
Problem Context	Personal
Information Environment	Physical resources
Item Format	Tap on stimulus
Answers	Taps on the following locations (in this order): 1) Shop B 2) Home
Estimated Difficulty	Low to moderate