

ETS POLICY REPORT

Level Up



Raising the Skills of Adults in the United States and Other Countries

Irwin Kirsch, Mary Louise Lennon, and Anita Sands,
with Jean-François Rouet, Anne Britt, Tobias Richter
Dave Tout, Kees Hoogland, and Javier Diez-Palomar

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Level Up: Raising the Skills of Adults in the United States and Other Countries

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Abstract

In an era of globally competitive and technology-driven societies, we are seeing a growing interest in developing a better understanding of the types of skills adults need to succeed both in the workplace and in everyday life. One large-scale comparative survey designed to inform that understanding is the OECD's Program for the International Assessment of Adult Competencies (PIAAC), a survey of adults ages 16-65 conducted in over 30 countries. PIAAC was designed for, and with, participating countries and represents a wide range of knowledge and skills that are required across a variety of adult contexts. The PIAAC data make it clear that adults with lower-level literacy and numeracy skills experience less favorable social, educational and labor market outcomes when compared with their more highly skilled cohorts. While some of those adults possess key foundational reading and numeracy skills, they would benefit from enhancing their skills so that they can more readily navigate, critically analyze, and problem solve in today's data-intensive, complex digital environments. This report describes a project in which two groups of experts – one in the domain of literacy and the other in numeracy – conducted analyses of the PIAAC data with the goal of defining the knowledge and skills associated with various levels of proficiency in those domains. The key purpose of this work is to form a foundation for the development of strategic interventions to improve adult literacy and numeracy skills. The argument made herein is that the insights gained from these expert analyses into the skills needed to transition to higher levels of literacy and numeracy can be leveraged to create a coherent learning and assessment system that could significantly enhance the literacy and numeracy skills of various adult populations.

Keywords: literacy, numeracy, technology skills, workplace skills, Program for the International Assessment of Adult Competencies (PIAAC), skills for adults, large-scale assessments

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While the utopian vision of the current Information Age was that computerization would flatten economic hierarchies by democratizing information, the opposite has occurred. Information, it turns out, is merely an input into a more consequential economic function, decision-making, which is the province of elite experts. . . . My thesis is not a forecast but an argument about what is possible: AI, if used well, can assist with restoring the middle-skill, middle-class heart of the US labor market that has been hollowed out by automation and globalization.

—David Autor, 2024

Introduction and Overview

More than a century ago as the world was transitioning from an agricultural to an industrial economy there was a growing need for the creation of tools, processes and machines that could produce a broad range of new products. This new era of production was dependent on individuals with the training and experience to build, operate and maintain these new machines. The growing need for new kinds of knowledge and expertise contributed to the introduction and growth of secondary education, the rise in the percentage of people with high school diplomas and the growing recognition of the importance of literacy and numeracy skills for adult populations (Autor 2024; Golden & Katz, 1998). Our dependency on education and skills has continued to grow and expand as modern societies have transitioned from the industrial age to the knowledge economy and more recently to an information age. With these transitions has come the expectation that most, if not all, individuals will need some form of post-secondary education, training or credentialing to thrive in the future.

Today, problem-solving, critical thinking, creativity, and communication are widely recognized as essential for success in both work and daily life. These higher order skills form the core of a skill profile valued in the modern world. However, what may be less appreciated is how deeply these higher-order skills depend on a solid foundation of literacy and numeracy. Strengthening this foundation is crucial—especially if, as David Autor suggests, the potential of AI to revitalize middle-class jobs is to be realized.

What International Large-Scale Assessments of Adult Skills Tell Us

Over the past several decades, policy makers, researchers and other stakeholders have increasingly understood the importance of the skill levels of their adult populations. In response, starting in the 1990s, a series of international surveys of adult skills were developed to establish profiles of adults within and across countries in terms of the knowledge, skills and competencies thought to underlie both personal and societal success (Kirsch *et al.*, 2017). The most recent in the series is the OECD's Programme for the International Assessment of Adult Competencies

(PIAAC). The first cycle of PIAAC was conducted between 2011 and 2018 in 39 countries and results from the second cycle, conducted in 31 countries and economies, were reported in December of 2024. PIAAC assesses adults ages 16-65 on three broad sets of cognitive skills: literacy, numeracy and problem solving. In addition to the direct assessment of skills, PIAAC includes a comprehensive background questionnaire that gathers information about participants' social, educational and labor market experiences, making it possible to examine the relationships between these various characteristics and outcomes. PIAAC builds on the experiences of two earlier surveys: the International Adult Literacy Survey (IALS), conducted in the 1990s, and the Adult Literacy and Life Skills Survey (ALL), conducted in the early 2000s. Each of these three international assessments are household surveys conducted under the supervision of trained interviewers who collect background information through a computer guided interview and then administer the cognitive assessment. The primary feature that sets PIAAC apart from the two earlier surveys is that it was designed to deliver the cognitive assessment on a digital platform. This feature provides the OECD and participating countries with the opportunity to broaden what can be assessed so that the results better reflect the kinds of competencies adults need to access, understand and use a broad range of information.¹ To help us understand how literacy and numeracy skills are distributed across all participating countries, PIAAC reports these results across six proficiency levels – Below Level 1 and Levels 1-5.²

PIAAC results help policy makers, researchers and others evaluate the extent to which key segments of our adult populations are prepared for the skills challenges that are currently confronting us and those that will likely lie ahead. Findings from PIAAC and the earlier surveys show large and significant advantages in education and labor market outcomes for adults who demonstrate higher levels of these skills. In addition to describing the literacy and numeracy skills of adult populations, the first cycle of PIAAC included a measure of problem solving in technology rich environments (PSTRE). Analysis of these data reveals a significant association between literacy and numeracy skills and performance on the PSTRE tasks. Specifically, participants who generally scored in the middle of Level 3 on the literacy scale tended to achieve around 50 percent accuracy on PSTRE items. This suggests that higher literacy skills are associated with stronger performance on tasks requiring problem-solving in technology-rich environments. (See Figure 1 in Appendix A). Such data reinforce our understanding that higher level skills rely on a strong foundation of literacy skills.

These and other findings from PIAAC raise important policy questions concerning the significant numbers and percentages of adults in participating countries who are at risk of being left behind. By 'left behind' we mean that insufficient skills do not enable adults to achieve their goals and participate in society, threatening societal cohesion and well-being as societal standards increasingly rely on those skills. "Left behind" also means that adults with low skills have less access to the job market and, when they do have access, less opportunities to develop or advance, to take advantage of affordances provided by AI, and to enjoy the benefits of more productive careers.³ These data also point to questions regarding the potential social and economic returns associated with developing effective interventions designed to raise the skills of adults with lower levels of literacy and numeracy proficiencies and how best to help these groups raise their skill levels so that they are better able to thrive in modern societies with their growing dependency on accessing, understanding and using digital information.

Insights from International Panels of Experts

Given the demonstrated relationships between literacy and numeracy skills and social, educational and labor market outcomes, it is not surprising that there have been several studies estimating the return on investment (ROI) that could be derived from moving lower skilled adults and students to higher levels of proficiency (see for example, Hanushek *et al.*, 2015, Hanushek & Woessmann, 2010; Rothwell, 2020). Many of these studies yield results that suggest potentially staggering gains in economic well-being by assuming that the various populations demonstrating low levels of proficiency would be able to advance to a higher minimal standard given appropriate intervention. Although it is a desirable goal, we believe that gaining a more nuanced understanding of the requirements for advancing adult skills, as well as the proportion of adults who can reasonably be expected to achieve this advancement, has the potential to significantly inform national and local efforts in developing successful programs aimed at improving adult skills.

As one effort to develop a more refined understanding, this paper describes the work of a panel of literacy and numeracy experts who conducted an extensive analysis of PIAAC Cycle 2 assessment tasks. The focus of their work was to describe and explain the skills that reflect performance at key proficiency levels along the literacy and numeracy scales. The underlying premise of the project was that developing an understanding of the progression of skills that is needed to successfully perform the kinds of tasks that people need to do at work, at home and in

their communities could form an empirically based foundation for linking the assessment frameworks with instruction that could be designed to help adults improve their skills.

The three literacy and three numeracy experts working on this project were no strangers to PIAAC. They all are recognized for their experience and expertise in their relative fields and each of them was a member of the subject-matter expert groups who developed the PIAAC framework documents, oversaw the development of the assessment tasks, and led the interpretation of the survey results. Collectively, they have years of experience in working on research in these areas, developing and evaluating curricula, and working with learners of various ages (see author's biographies at the end of this paper). In particular, the experts' work on developing the domain frameworks provided the lens through which their analyses could be conducted. It is in the framework documents that each domain is defined, the important skills within the domain are identified, and the blueprint for the assessments is developed, which sets forth the characteristics, types, and number of test items needed to measure those skills. For more information about the framework development process and the features described for each domain, see Table 1 in Appendix A.

Organization of the Paper

The previous discussion provided a brief introduction and overview of the PIAAC assessment and the critical role expert groups play in the development of the cognitive instruments. Next, the paper presents a brief overview of the literacy and numeracy scales along with analyses based on the PIAAC Cycle 1 that support the view that Level 3 represents a key benchmark along each scale and why we believe focusing on moving young and prime working-age adults from Level 2 to Level 3 is an appropriate strategy in order to ensure they have the skills needed in today's societies. The paper also introduces the idea that insights gained from the extensive analysis of skills associated with the various levels can be leveraged to create coherent learning and assessment systems that could effectively enhance the literacy and numeracy skills of various subpopulations of adults both in the United States and other participating countries. The paper then presents findings from the extensive analysis of each scale, focusing on the factors that drive task complexity and difficulty along with the skills that differentiate proficiencies across a set of levels with an emphasis on Levels 2 and 3. The final section of the paper presents an intervention strategy that could be developed and used with various adult populations that builds on evidence-centered design (ECD) principles (Mislevy et.al., 2003) that

are used in the development of the frameworks for each cognitive domain.⁴ The goal of the proposed strategy is to use those ECD principles to develop and link high quality instruction, professional development and assessment materials (both formative and summative) to the literacy and numeracy frameworks.

Understanding and Using the PIAAC Frameworks to Interpret Results

Large-scale national and international surveys such as PIAAC employ a statistical model that makes it possible not only to summarize the literacy and numeracy proficiencies of the total adult population along with various subpopulations, but also to determine the relative difficulty of the literacy and numeracy tasks that were administered as part of the PIAAC survey. That is, just as individuals receive an estimate of their proficiency according to their performance on the assessment tasks, each task that is used in the assessment receives a value that places it on the same scale according to its difficulty, as determined by the performance of the individuals across countries who participated in the survey. Research has shown that the difficulty of all tasks, and therefore placement on each respective scale, is impacted by a set of factors that is described by the experts in each framework paper (Kirsch *et.al.*, 2001b).

By assigning values to both individuals and tasks, it is possible to see how well adults who demonstrate various levels of proficiency performed on tasks of varying difficulty. That is, we can examine the likelihood that a subgroup of adults at selected levels along each scale perform on tasks at, above and below their estimated level of proficiency. The data reveal that while individuals with low proficiency tend to perform well on tasks with a difficulty value equivalent to or below their level of proficiency, they are less likely to succeed on tasks with higher difficulty values. In other words, the lower the difficulty of tasks relative to their proficiency the higher the likelihood that they will perform them correctly. Conversely, the higher the difficulty of tasks relative to their proficiency on a scale the less likely they are to perform them correctly. Tables 2a and 2b in Appendix A demonstrate this relationship for a selected set of items on the literacy and numeracy scales. Understanding these relationships provides the experts and other researchers with an opportunity to examine the difficulty factors that drive performance on the items and to better understand the specific skills that are associated with the progression of skills along each scale.⁵

When trying to interpret PIAAC results it is important to keep in mind that all the main study data is collected from nationally representative samples of adults in each participating

country. Moreover, the sets of items associated with each of the cognitive scales are developed and selected to be representative of each construct as defined and operationalized in their respective framework. Thus, just as the results from the weighted sample of adults are used to describe and characterize the literacy and numeracy skills of the total and selected subpopulations within and across each country, the tasks that are used to scale each domain represent a sample of possible tasks and thus can be generalized to the full set of tasks that could be developed using the blueprint or roadmap provided by each framework. In addition, because the tasks focus on the real-life literacy and numeracy skills defined in the frameworks, performance on those tasks can also be generalized beyond an assessment context to real-world skills and knowledge.⁶

The Importance of Literacy and Numeracy Skills: Selected PIAAC Results

PIAAC results support the growing importance of skills and the view held by many that individuals with lower levels of literacy and numeracy skills are at risk of being left behind as societies continue to undergo rapid change. Data in the US, for example, show that those with lower levels of literacy and numeracy skills (below Level 3) experience less favorable labor market outcomes than their higher skilled peers including higher rates of unemployment, lower labor force participation rates and lower earnings even when they report the same level of educational attainment. For example, the mean monthly earnings of college graduates with literacy skills below Level 3 are 15 percent lower than those with Level 3 skills, and 37 percent lower than those with Level 4/5 skills. In numeracy, the differences are even greater: college graduates with low numeracy skills earn 18 percent less per month than those with Level 3 skills, and 44 percent less than those with Level 4/5 numeracy skills (Fogg et. al., 2019; Fogg et.al., 2018).

In addition to labor market outcomes, PIAAC data show that those in the US with higher literacy and numeracy skills: confront fewer roadblocks in pursuing their educational goals; have lower rates of incarceration; are more likely to participate in lifelong learning and keep abreast of social and political events; have increased levels of trust and civic engagement; and, are better able to navigate aspects of their daily lives including managing their health care and family finances (Autor, 2019; Hanushek & Woessmann, 2008; Kirsch et.al., 2016; OECD, 2016; OECD, 2019a,b; US Department of Education, 2015).

According to PIAAC Cycle 1 data, there are some 120 million prime working-age adults (25-54 years of age) in the US. Among them, some 32 percent, or 38 million, are in Level 2 in numeracy and 31 percent, or 37 million, are in Level 2 in literacy. Among younger adults ages 16-24 the problem is a bit worse. Some 37 percent, or 14 million, demonstrate numeracy and literacy skills in Level 2. (See Table 3 in Appendix A).⁷

As we advance deeper into the 21st century, a troubling and paradoxical shift appears to be emerging: At a time when higher levels of skills appear to be critical for the long-term success of individuals—and the US as a whole—we appear to be losing ground despite rising enrollment and attainment rates for those seeking post-secondary education and training. There appears to be a similar problem among many of the countries participating in PIAAC. As Figure 2 (in Appendix A) shows, we estimate that there are 100 million or more adults in these countries who are in Level 2 on both the literacy and numeracy scales. Perhaps the most salient finding from PIAAC and other adult surveys is that they highlight the mismatch between the literacy and numeracy skills demonstrated by so many adults across the participating countries and the increasing demands expected in globally competitive, technology-driven societies

Significance of Level 2 Skills

So why focus on the adults in Level 2 and not on all adults below Level 3? Based on the research literature and the experiences of the authors of this report, we believe that the majority of adults who demonstrate literacy and numeracy skills in Level 1 and below face a number of challenges involving one or more of the foundational skills associated with literacy and numeracy (Magliano et al., 2022). These foundational, or component skills, include basic vocabulary knowledge, fluent sentence processing and passage comprehension, and basic number and spatial sense. In contrast, those in Level 2 demonstrate higher levels of these skills – ones that are closer to adults in Levels 3 and higher. For example, researchers at the National Center for the Study of Adult Learning and Literacy (NCSALL) reported on a study of 1,034 adults that was designed to better understand the relationship between the component skills of reading comprehension and the measure of prose literacy in IALS. All participants received the IALS prose literacy measure along with a battery of reading component measures (Strucker et al, 2007). Among their findings, they concluded that higher levels of proficiency in these reading component measures represent “tipping points,” or thresholds, that need to be reached in order to perform Level 3 prose literacy tasks.⁸ In addition, a more recent study (Wang et al, 2019) showed

that middle-school students who fall below a decoding threshold demonstrate lower comprehension skills and, more importantly, fail to significantly improve their comprehension skills over time compared to students who score above the threshold (See Figure 3).

While we argue that helping adults at Level 2 improve their proficiency and attain Level 3 skills is beneficial in terms of a range of life outcomes, an important question is whether we believe that such an effort would be successful with a significant percentage of the Level 2 population. Two efforts aimed at this goal provide some insight into that question. Two of the authors of this paper had the opportunity to develop a computer-based learning system with the support of ETS and Apple Computer from 1988 - 1994 (Kirsch & Lennon, 1992). The group-based system consisted of computer-based learning materials based on the IALS prose, document and quantitative literacy frameworks and the analysis of factors driving difficulty on the tasks in that assessment (Kirsch, 2001b). One finding from this work was that individuals at Level 1 tended to find the instruction too challenging, while those at Level 3 or above found it too easy. Participants at high Level 1 and Level 2 seemed to benefit most from the instruction.

The system was evaluated using a teacher from each of 12 adult education programs across the country who volunteered to use this experimental system. Each of the teachers came to ETS for a week to receive training on the system and the lessons and then went back to their programs to implement the instructional system with at least one class of students. The adult learners participated in cognitive labs, designed to determine their strategies for accessing and using information both pre- and post- instruction, and more formal pre- and post-tests that indicated if individuals performed in Level 1, Level 2 or Level 3 and above. These unpublished pilot studies demonstrated that some 80 percent of participants showed significant skill gains on post-tests, with average scores increasing by one-half to three-quarters of a standard deviation.⁹ Significantly, follow-up studies showed that gains were maintained up to 6 months, suggesting that participants applied and continued to hone their skills over time. Also importantly, in follow-up interviews, instructors and supervisors reported that participation in the program helped adult learners improve their self-confidence, along with their teamwork and communication skills. We believe that the success of the system stemmed from the fact that it provided learners with generalizable strategies and tools and gave them a language for thinking about how they use information - in other words, a strong set of meta-cognitive skills. As this initial effort suggests, applying a similar approach to the development of a new learning and assessment system using

the PIAAC constructs seems not only highly feasible but also one that is likely to yield a significant return on investment (ROI).

To help support our position on an intervention strategy that focuses on higher level learners, the numeracy experts suggest that a second intervention to consider is the Victorian Certificates of Applied Learning (VCAL), which is recognized within the Australian Qualifications Framework (AQF), the national policy that governs the recognition of educational qualifications in Australia.¹⁰ The program was tailored for students between ages 16 and 18 seeking practical, hands-on learning that prepares them for employment or further education, and was structured around applied learning principles, with an emphasis on employability and vocational skills across real-life contexts, including workplaces, community projects, and industry settings. The VCAL framework is divided into four key educational strands: literacy and numeracy skills, industry-specific skills, work-related skills, and personal development skills across three levels—Foundation, Intermediate, and Senior—each catering to different skill levels and progressively building students’ skills. Assessments in the VCAL program are central to measuring students’ mastery of learning outcomes in applied, real-world skills and focused on gathering diverse evidence of achievement—such as through direct observations, written work, oral presentations, product creation, project implementation, and, for some, summative assessments—to ensure students meet specific, practical learning goals.¹¹

One of the co-authors of this paper analyzed the success rate of VCAL, which included a focus on literacy and numeracy practice that is similar to the PIAAC domains of literacy and numeracy. While the proficiency levels for the VCAL course are not identical to those reported in PIAAC, two of the levels (Intermediate and Senior) were judged to be reasonable proxies for PIAAC Level 2 and 3. Therefore, an analysis of success rates in completing those two VCAL levels could provide insight into the potential success rate of the proposed strategy for developing targeted interventions. Looking at the published data on completion rates from 2019 through to 2022 for the units in each semester, the success rates for Intermediate Numeracy units ranged from 69.3% up to 76.9% over the year. This compares with a success rate ranging from 79.2% up to 88.3% for the Senior level. These results seem to suggest that the expected success rates of the proposed intervention program of between 60-80% is not unreasonable, and in fact would most likely be at the higher end when moving adults from Level 2 to 3 (70-80 percent)

and even higher when progressing from Level 3 to 4, compared to moving adults from Level 1 to Level 2.¹²

Collectively this work leads us to believe that insights gained from the extensive analyses of the skills associated with various levels of proficiency can be leveraged to develop programs that can enhance the literacy and numeracy skills of significant percentages of young and prime working-age adults both in the US and elsewhere. In addition, this work suggests that participants who possess Level 2 literacy and numeracy skills are best positioned to benefit from instruction designed to improve those skills. The next section of this paper integrates and summarizes the work of each expert group that focused on examining the tasks on each scale more closely and identifying features and differences across the proficiency levels, especially those associated with transitioning from Levels 1 to 2 and Levels 2 to 3.

Literacy and Numeracy Skills

In order to develop an intervention to move a significant number of adults from Level 2 to Level 3, a clear understanding of the skills in each of those levels is required. As noted previously, literacy and numeracy experts each analyzed the PIAAC Cycle 2 items in their respective domains in order to identify the factors that explain the types of skills required to perform at each of these levels. As a result of their efforts, the experts

- identified a set of foundational skills that underlie both literacy and numeracy skills,
- described and explained a common set of factors that drive complexity in both domains,
- defined factors that are unique to each domain, and
- highlighted key skills that define the transition from Level 2 to Level 3 in literacy and numeracy.

Each of these four aspects of their findings is discussed in the sections below.

Foundational Skills

The experts identified a set of five foundational skills, or enabling factors, that are needed to perform literacy and numeracy tasks across all levels of proficiency. These include memory skills, fluency, vocabulary, familiarity, and dispositions, beliefs and attitudes.

Memory Skills

Memory includes several subsystems, including short-term, working, and long-term memory, and ensures the encoding, storage and retrieval of information, supporting the

comprehension of written texts. Working memory becomes more important the longer and more complex a text is, especially when a task requires establishing coherence across longer pages of text or across multiple documents. For tasks that require the comparison, evaluation, or integration of sources, not only the information itself but also the source needs to be encoded and actively recalled.¹³

In relation to numeracy, neuroscience has highlighted the importance of moving basic information and facts from working memory into long-term storage. If answers to basic calculations can be automatic and simply retrieved from long-term memory and do not need to be calculated, working memory can be better utilized to solve more complex problems. (e.g., see Sousa, 2007; Willingham, 2008). However, this does not mean that the solution is to teach math facts and skills through rote learning. The way to improve automaticity and fluency includes approaches such as making connections and recognizing patterns. Understanding relationships between concepts helps learners encode information more effectively in memory. Similarly, “chunking Information” and interleaving improves working memory capacity. Neuroscience also tells us that emotions can significantly influence memory retention—positive emotional experiences related to mathematics can enhance engagement and retention, while anxiety can hinder performance—and we know there is a significant issue with regards to math anxiety for many young people and adults.

Fluency

Fluency, or automaticity, is also important for both literacy and numeracy. In literacy, fluency may be broadly defined as the ease and accuracy of making meaning from written words (Pikulski & Chard, 2005). The more fluently people can read, the more cognitive resources they have available for higher-order comprehension processes, such as drawing inferences or reasoning about a text. For less fluent readers, reading is effortful and strenuous, especially for longer texts, which may lead to shallow reading or giving up before the information relevant for the task at hand has been processed.

Similarly, in numeracy, fluency or automaticity is commonly related to the concept of number sense. Broadly speaking, number sense is seen as relating to a person’s general conceptual understanding of different types of numbers and arithmetical operations and it involves critical understanding in order to make decisions and solve problems using numbers in efficient and flexible ways across personal, work, and societal/community contexts (OECD,

2021; Ontario Ministry of Education, 2006; Peters, 2012; Wagner & Davis, 2010; Yang, Reys, & Reys, 2009). One set of foundational numeracy items included in PIAAC relied on a more fundamental interpretation - that number sense relates to a sense of quantities and how numbers are used to represent and compare quantities. Number sense underpins many other aspects of mathematics and numeracy, especially in relation to data, chance and measurement. As per literacy, without this foundational knowledge, understanding and completing numeracy tasks requires greater effort and may contribute to a reduced chance of success.

Familiarity

The degree of familiarity that individuals have with a text's content or a numeracy problem scenario describes how well their prior knowledge and experiences match the content of the text or problem. In literacy, prior knowledge is an extremely important ability that is a strong predictor of reading comprehension outcomes (O'Reilly, Wang, & Sabatini (2019; Shapiro, 2004). Similarly, numerate behavior and practices also reflect exposure to numeracy practices and mathematical information across a variety of adult contexts.

Vocabulary

A source of individual differences that is closely linked to prior knowledge or experience is vocabulary. Having a broad vocabulary means that individuals know and are able to access the meanings of many words, including the meanings of relatively infrequent words. Comprehending a text that contains many unfamiliar words is challenging, making it more difficult to understand and evaluate information. In the case of numeracy, understanding the meaning of informal and more formal mathematical words and terminology is an important factor underlying skilled performance (Peng, P., & Lin, X. 2019). The important role of language is explored further in the numeracy working paper (Tout et.al, 2024 in preparation).

Dispositions, Beliefs, and Attitudes

The ways in which individuals respond to a literacy or numeracy task, including overt actions as well as internal thought processes and the adoption of a critical stance, depend not only on their knowledge and skills but also potentially on their disposition and attitude towards reading and mathematics. Negative attitudes, beliefs about one's skills, and habits of mind are all key influences on engagement, motivation and performance. This is a known major issue in relation to mathematics and numeracy performance, where mathematics anxiety is an acknowledged barrier and challenge (e.g., see: Buckley, 2013; Ma, 1999; Tobias, 1993).

Common Factors Driving Complexity in Both Domains

Across both domains, a set of common factors influences the complexity of tasks and suggests areas of focus for instruction. For example, understanding a task statement or goal can play a crucial role in successful performance. In some cases, the goals to be accomplished are clear and direct, while in other instances, they are implicit and require some interpretation. In addition, some tasks require the identification of one piece of information, whereas others require the integration of multiple passages. Thus, features of a given task influence how easy or difficult it may be to complete that task. As noted in the working papers from the experts, in the context of PIAAC, tasks consist of the questions or directives posed to test takers. These are designed to reflect a range of real-life literacy and numeracy tasks encountered by adults as those are defined in the domain frameworks. As a result, the conclusions drawn about the skills required to complete tasks of varying difficulty across the proficiency scales apply not only to performance on the assessment but can be generalized to other real-world tasks and the skills adults need to successfully complete them.

A second factor that impacts complexity relates to the features of a text or texts that appear to make a task easier or harder to complete. A task may be more difficult if it requires the use of one or more texts that are complex or lengthy, focus on an uncommon topic, or use complex and unfamiliar language. Tasks associated with multiple sources of information are more difficult if they require a decision about which source or which data are relevant. It should be noted here that, throughout this paper, references to texts include two distinct categories of materials. The first is what one would typically think of as reading material. This includes brochures, newspaper and magazine articles, web pages, blogs, etc. where information is presented in sentences that are typically organized into paragraphs. These types of texts are sometimes referred to as continuous information. The second category includes texts that present information in lists or matrix formats and includes tables, charts and graphs, and schematics. These non-continuous materials often include numerical information and, as such, in PIAAC, these are most common in the numeracy domain. But in everyday life, both literacy and numeracy tasks may be associated with both continuous and non-continuous texts in both digital and print formats.¹⁴

In both literacy and numeracy, not only are features of both tasks and texts important to consider, but the interaction between the two impacts difficulty. For example, an individual may

want to locate a particular number or piece of information on a website with multiple pages. If that information is positioned in a prominent location on the home page of the website, that locate task could be quite easy. Conversely, if a user needs to navigate through multiple pages, perhaps using prior knowledge to select the most likely location for the information, that same task will be much more difficult.

Difficulty may also be impacted for both literacy and numeracy tasks by the presence or absence of what are referred to as “distractors”, or plausible information that one might mistake for the target information. For example, when the numbers required to undertake an arithmetic operation must be extracted from material that contains a range of similar, but irrelevant, numbers, the task becomes more difficult. Similarly, in literacy, when a task requires a reader to locate a specific key word or phrase in the text, if that word or phrase can be found in multiple locations, particularly if some of the incorrect instances are located prominently in the text (such as in a heading or in the initial sentences of the text), the task is more challenging than if that information is in a single location.

Finally, literacy skills are factors that impact difficulty in both domains. It is obvious that such skills are central to literacy tasks, but the numeracy experts emphasize their role in numeracy tasks as well. Some numeracy tasks may involve pure quantitative or mathematical information that is to be interpreted or acted upon with virtually no text or linguistic input. In these cases, the individual derives all the information needed to respond from the images or objects present in the situation or from direct numerical or visual displays. However, in cases where mathematical representations involve text, performance will depend not only on formal mathematical or statistical knowledge but also on reading comprehension and literacy skills, reading strategies, and prior literacy experiences. For example, following a computational procedure described in text (such as the instructions for computing shipping charges or adding taxes on an order form) may require special reading strategies, as the text is very concise and structured. Likewise, analyzing the mathematical relationships described in words requires specific interpretive skills, as in the simple case of recognizing the similarity of “the price doubled” and “the price was twice as much”, but can be more complex in the different meanings in “production levels were constant over the last five years” and “production levels increased at a constant rate over the last five years”. Real-world situations and demands do not neatly divide into discrete ‘literacy’ and ‘numeracy’ tasks but require the integration of skills across domains.

As noted previously in this paper, both the literacy and numeracy scales reflect a progression of skills or behaviors that individuals need in order to successfully complete tasks that vary in difficulty. For each domain, the skills associated with Levels 1, 2 and 3 on the proficiency scales are identified and discussed in the following two sections. Given that the aim of the proposed intervention strategy is to help individuals with Level 2 skills develop Level 3 skills, it is particularly important to understand what differentiates Level 2 from Level 1 and what is required to successfully perform at Level 3. Individuals with Level 2 skills are likely to be able to successfully complete Level 1 tasks and even more likely to perform tasks that are Below Level 1. They are also highly likely to possess most, if not all, of the foundational skills including fluency, sentence comprehension and basic number sense that are included in the component measures of the PIAAC Cycle 2 assessment.

Literacy Skills at Levels 1, 2 and 3

Analyses of the PIAAC Cycle 2 literacy results focused on the three main drivers of proficiency discussed earlier: the characteristics of the texts that readers need to use, the complexity of the tasks they are trying to accomplish, and the ways in which the interaction between a task and text(s) can make the purpose or goal of accessing, understanding or evaluating information easier or more challenging.

Description of Text Features and Related Literacy Skills at Levels 1 Through 3

Three features of texts were identified by the expert group as impacting the performance of readers at Levels 1, 2 and 3: text length, topic novelty, and number of sources. Performance at each level, based on these three text characteristics, includes the following.

At **Level 1** of the PIAAC proficiency scale, readers can access and understand information in short texts of less than 200 words set in common contexts and presented on a single page. Examples include a list of information or a collection of two or three very short independent passages such as descriptions of three different photography classes in a class catalogue. Texts at this level typically come from a single source.

At **Level 2**, readers can go beyond short texts and deal with longer narrative, descriptive or explanatory texts, including texts distributed across two digital pages. Accessing relevant information may require scrolling or clicking on tabs. Readers can access and understand information arising from multiple sources (e.g., forums or document sets). Level 2 readers can

also make use of simple tables and charts. Texts at Level 2 may deal with unfamiliar situations, but the vocabulary remains familiar and easy.

At **Level 3 and above**, readers can understand lengthy multipage texts arising from different sources. The texts may deal with unfamiliar topics, use difficult language and may present multiple conflicting claims supported by arguments. In the most complex tasks at this level, readers can use source information to interpret discrepancies across texts. Importantly, whereas most texts at Level 2 involve one driver of complexity at a moderate level, texts at Level 3 are likely to include several drivers (e.g., both long and unfamiliar) and are often distributed on more than two pages.

Description of Task Features and Related Literacy Skills at Levels 1 Through 3

As stated earlier, in their daily lives, adults most often engage with texts having a specific purpose or goal in mind. They may want to know the schedule for trash collection in their town or compare the policy positions of two candidates running for local office. In the PIAAC study, reading purpose is communicated through questions that test takers answer using one or several texts that are made available to them. Questions are designed to prompt one of three main categories of cognitive processes (OECD, 2021, p. 45): accessing information within the text; understanding (including literal and inferential comprehension) or evaluating text information. In absolute terms, the PIAAC data suggest that there is a hierarchy of difficulty among these categories of processes. Up to Level 2 of the literacy proficiency scale, most tasks require only accessing or understanding of text information. Evaluation is represented more often and in more diverse forms from Level 3 on. At Level 3, readers perform mostly content evaluation on the basis of a single document. More complex forms of evaluation (e.g., inferences about multiple information sources) correspond to the upper end of Level 3 and above.

Besides the core cognitive process targeted by the question, reading literacy tasks differ on three types of task features: question complexity, complexity of the reading goals needed to perform the task and the strategy required to find information of interest.

At **Level 1** of the proficiency scale, readers can deal with simple and straightforward questions that sometimes come with explicit instructions as to where to look in the materials. These tasks only require the location and understanding of a single piece of information, which may be achieved by simply scanning the text without considering any structural or navigation components.

Level 2 still involves simple questions asking mostly for the location and/or understanding of a single passage in the text. However, some questions at this level are longer and present more information that readers need to parse; they may require the location of two target passages or pieces of information or the completion of two steps in order to locate the target. When this happens, the use of text signals or navigation devices may be required in order to locate information of interest.

More complex tasks begin at **Level 3**. Some questions ask the reader to not just locate and understand information, but also to evaluate content information against various types of criteria. Questions may include more information, such as an introductory scenario or contextual information. In addition, the provided response options for a given question may be more complex and challenging to evaluate. The question's intrinsic difficulty may come with another driver of complexity, such as the need to complete multiple steps, for instance to locate more than one target, making use of text signals such as headings or tabs or navigation devices.

Description of Task-by-Text Features and Related Literacy Skills at Levels 1 Through 3

A number of additional dimensions characterize the relationship between a task and the text(s) needed to perform that task. These can be grouped into three categories.

- **Indirect match, inferencing, reasoning:** This category focuses on the relationship between what is being asked in the question and the information mentioned in the text. Sometimes a question may be readily answered by locating or matching information in the text. In other cases, inferencing or reasoning skills are required. Simple inferences include substantial paraphrasing, temporal ordering, connecting causes and antecedents, and categorization. More complex inferences consist of extracting the gist from several sentences or interpreting characters or authors' motives from indirect cues.¹⁵
- **Need to relate distant pieces of information:** Some texts provide all needed information in a single location thanks to author-generated cues, e.g., consecutive words in a sentence or sentences within a paragraph or a single table cell. Other texts require the reader to identify and use multiple pieces of information distributed across paragraphs, messages, or even pages in a website type of environment. At an advanced level, readers must integrate pieces of information distributed in distant paragraphs or on multiple pages.
- **Amount and salience of distracting information:** Distracting information is information contained in the text that resembles the target information. Information may

be distracting because it shares a content word with the question, or a visual feature in the case of pictures. Distracting information may be easier or harder to discard, depending on its position in the text and on how closely it resembles the target.

The literacy skills related to task-by-text features for these levels are summarized below.

At **Level 1**, task-by-text interactions are often unproblematic. The wording of the question or directive typically directly matches information in the text. There is no need to relate distant pieces of information. Rather, information to be integrated is located in a single sentence or in the same section of a table. At most, some tasks require a simple inference or the text contains some easy-to-discard distracting information.

At **Level 2**, a majority of tasks involve at least one interaction with the text, but these are at most at an intermediate level of difficulty. Questions involve diverse types of inferences or the integration of several ideas into a single claim or point. Inferences go beyond connecting related words. Instead, the pieces of information to be connected are found in adjacent paragraphs or on a single page. Some texts at Level 2 contain distractors. However, in most cases, they can be disregarded if readers go slightly beyond surface processing.

Readers at **Level 3** must be prepared to deal with either substantial inferences or reason about extended portions of text. Tasks may require that they conduct multiple cycles of locating and integrating information across passages of text. Texts at Level 3 may include multiple distractors that share a high level of resemblance with target information and are sometimes in prominent positions such as in headings, on tabs, or in the initial sentences of a text. Therefore, some thinking is required on the part of the reader in order for such distracting information to be discarded.

Transitioning From Level 2 to Level 3 Literacy Skills

In order to move from Level 2 to Level 3, adults must develop the skills to handle longer and more complex texts, more complex tasks or questions, and more complex interactions between tasks and texts. Skills associated with more complex texts are apparent from Level 2 and above. However, adults at Level 3 can handle multipage texts presenting contrasting or even conflicting viewpoints. They can assess the quality of arguments and the credibility of information sources.

Adults at Level 3 can also address more complex comprehension tasks. Notably, they can deal with lengthy questions that require them to evaluate text content against various criteria.

They can also deal with questions that require multiple processing steps, making use of text signals or navigation devices.

Finally, adults at Level 3 can generate deeper inferences, connect distant pieces of information and avoid multiple distractors even when those are located in prominent positions. Most importantly, a core distinction between Levels 2 and 3 lies in adults' ability to handle tasks that involve multiple constraints, e.g., a complex question about a long text. Identifying these constraints and knowing how to deal with them is key to adults' transition across these levels.

Description of a Sample Literacy Text With Items at Levels 1, 2 and 3

The three items described here are all associated with the same text, illustrating how task-by-text features can impact the difficulty of items. The text in this example consists of a short section of a brochure with information about an electric bicycle rental program. The text is short, consisting of 129 words in total, and includes general information describing the program, provides some specifics about how the program works and identifies where interested individuals can get more information.

Level 1 item

The brochure explains that bicycles are stored at stations around the city, with a number of bases at each station. Respondents are asked to identify the number of bases in the city. This question is quite easy for a number of reasons: the text is short; the task is clear because the key phrase “how many” in the question indicates that a numerical response is required; the task and text are closely related as the text includes only a few numbers; and the key word “bases” is used in both the question and text, making the correct information easy to locate.

Level 2 item

A somewhat more difficult item in this set asks respondents to identify one way people can find out more about the program. As per the Level 1 item described above, the text is short but, in this case, the task-by-text relationship is less clear. That is, the question wording does not signal the location of the correct information as directly as in the previous item. A simple synonymous match is required to connect “one way *people* can find out *more*” in the question with the phrase “*users* can get *more information*” in the text. In this case, the match is not difficult, making this an easy Level 2 item.

Level 3 item

The most difficult item in the set asks respondents to identify the main goal of the program. A low-level inference is required to select the sentence with this information as that sentence focuses on the “primary objective” of the program. The text also includes some distracting information as a secondary goal is also identified. Respondents must focus just on the primary, or main, goal in order to answer correctly.

Numeracy Skills at Levels 1, 2 and 3

In traditional mathematics education, the difficulty of any given task is often viewed as being driven by the complexity of the mathematics involved. The perspective taken here, as has been previously discussed, is that the complexity of a numeracy task is also driven by features of the task statement, or the goal an individual is trying to achieve, features of the text(s), and the interaction between a given task and text.

Description of Text Features and Related Numeracy Skills at Levels 1 Through 3

Quantitative and mathematical information in real world situations and contexts is always represented and embedded in some format or other, whether that be in images, words and text, diagrammatically, graphically, or dynamically. Mathematics per se, does not exist in the real world by itself in its own isolated, abstract form such as $80\% \times €7.80$. Such mathematics will be most likely embedded in an advertisement saying “20% discount” and the reader will need to read the information and decide that the solution is to take off 20% of the original price of €7.80. Hence the PIAAC framework elaborated on the different ways that mathematics can be represented in the real world in a numeracy situation. Each of these can be considered a type of “text” in the context of the numeracy tasks.

Four types of representations or “texts” are identified in the numeracy framework and were used in the PIAAC items:

- Structured information was the representation upon which the majority of PIAAC tasks were based and includes the non-continuous types of texts discussed earlier: tables, graphs/charts, maps, plans, calendars, schedules, timetables, infographics, etc.
- Dynamic applications were included for the first time in PIAAC Cycle 2 because the assessment was delivered on a tablet. These included interactive applications, spreadsheets, calculators and so forth. They reflected other types of representations but differed in that they could be manipulated and changed. So, for example, an item might be based on a table (structured information) but the data in that table could be sorted and reordered using the dynamic functionalities that were provided.
- Text or symbols consisted of continuous texts (with information presented in sentences and paragraphs) where numerical information and symbols are integrated into the text.

- Images of physical objects include photos or images that contain information crucial to solving the presented task. A set of illustrations of boxes with labeled dimensions is one example of this type of representation in this category.

The characteristics of text features across the numeracy proficiency levels are as follows.

At **Level 1**, adults can read and interpret mathematical information that uses simple, familiar and non-formal language and symbols. The information is set in authentic and mainly familiar and commonplace contexts, where the mathematical content is explicit with little text and minimal distracting information. Texts may include very simple bar graphs, lists of dates, and tables with only a few rows and columns of information.

At **Level 2**, information may be presented in slightly more complex forms (e.g., doughnut charts, stacked bar graphs, multiple charts, or linear scales) and use more formal terminology, language or symbols. The information may be less familiar or common and can be partially embedded or located within a number of sources.

At **Level 3**, adults can read and interpret information, representations and terminology that are more formal and involve greater mathematical complexity, including algebraic representations and conventions. Contexts are often less common or familiar and information can be embedded within a number of sources.

Description of Task Features and Related Numeracy Skills at Levels 1 Through 3

As is the case with literacy tasks, in their daily lives, adults approach numeracy tasks with a specific purpose or goal in mind. For example, they may want to know how the discounts for two products compare or if the conclusion presented in a newspaper article is supported by the graph included in the article. The difficulty of numeracy tasks is driven by several features including: The complexity of the question, the explicitness of the mathematical requirements (e.g., does the task include key words such as “total” or “difference” that signal a computational requirement or not); the mathematical knowledge, including the type of operation or skills, that is required; and the expected number of mathematical operations or processes required to solve the task. It is important to note that understanding the presented task and discerning the type of calculation or process (or sequence of operations) necessary to reach an appropriate answer can often be challenging. For example, an individual might possess the knowledge to apply proportional reasoning but recognizing that proportional reasoning is required to solve a

particular task is a different matter, particularly when that is not explicitly stated in the task's description.

At **Level 1**, adults can respond to simple, closed questions requiring them to identify or locate information. They can complete tasks utilizing some level of interactivity. For example, they can locate and click on relevant information on a webpage or use an online ruler for measuring. They can devise simple strategies, using one or two steps, to determine a solution. At this level, adults are able to use small whole numbers, decimals and common fractions and percentages (such as $\frac{1}{2}$ and 50%) to count, compare quantities, perform basic operations (addition, subtraction, multiplication and division), and interpret simple spatial representations and scales.

At **Level 2**, adults can access, act on and use information and evaluate simple claims. They can respond to questions that require a level of interpretation and complete tasks utilizing different levels of interactivity. They can use larger numbers and demonstrate an understanding of their relative size (e.g. comparing one thousand to one billion). These individuals can read, select and use data from simple tabular and graphical representations, use numbers to make estimates, and are able to understand and interpret basic formulae (e.g. areas of regular polygons). Level 2 tasks may require individuals to interpret representations and visualizations. Typical mathematical processes required at Level 2 include applying two or more steps where multiple conditions need to be satisfied.

At **Level 3**, tasks are increasingly likely to require prior knowledge in order to reach a solution. Level 3 adults are able to complete tasks that require satisfying different criteria. They can complete tasks that require the use, integration, or manipulation of data sources in order to undertake the necessary mathematical analyses. They can respond by utilizing different levels of understanding and interactivity with a more technical, dynamic representation where interaction and interpretation is required e.g., spreadsheet processes.

Description of Task-by-Text Features and Related Numeracy Skills at Levels 1 Through 3

The task-by-text features in numeracy pertain to the process(es) a respondent must undertake to connect the required action in the question, or task, to the relevant information in the text. This can range from a straightforward action, such as locating or matching information, to more complex actions requiring multiple searches through the provided data. This measure of complexity in a numeracy task also includes the extent to which mathematical information is

embedded within the text and the number of plausible distractors that exist in the text. To improve their skills, adults must develop the abilities associated with comprehending the requirements of a task, understanding and using information in the presented text or data source, and determining the appropriate mathematical procedure to arrive at a satisfactory answer, decision, or action—such as identifying the relevant operation, or interpreting and reasoning with data. These factors are fundamental in progressing from one level of numeracy performance to a more advanced one.

At **Level 1**, adults can respond to simple, closed questions requiring them to identify or locate straightforward information. Relevant operations are clearly specified in the task and the numbers required to complete those operations are easy to locate in the text. In the easiest tasks at this level, no distracting information is present in the materials - everything that is needed to answer the question is in the text with no, or little, irrelevant information. No other mathematical information is present apart from that requested, making the required numbers or data easy to identify.

At **Level 2**, tasks become more difficult as the number of distractors in the text increases. Those distractors may share more features with the required information, making them more challenging to disregard. In addition, the required operation or set of operations required to complete a task are less explicit and must be determined based on an understanding of both the question and the available information or data.

At **Level 3**, adults are increasingly able to solve problems where the tasks or questions asked are more complex, where mathematical processes require the application of two or more different steps and where multiple conditions or multiple sources may need to be accessed. Task difficulty may be driven by the fact that irrelevant information may be present in both the question and the text. For example, when the numbers required to undertake an arithmetic operation must be extracted from material that contains a range of similar, but irrelevant, information, the task becomes increasingly difficult. In addition, the required mathematical information may be located in several places throughout the available text or texts. In more difficult tasks, the values required to complete the task may need to be derived from other values and the required operations may need to be inferred by the individual, relying on an interpretation of the context and of the kind of response expected.

Description of a Sample Numeracy Items at Levels 1, 2 and 3**Level 1 Item**

A very short visual advertisement for a bike tour is presented that consists of a list showing the number of kilometers that bikers will ride each day on a three-day tour. The numbers are all two-digit whole numbers. Respondents are asked the number of kilometers in the complete tour. They must determine that “complete” means that they need to add the three provided distances in order to compute the total. This task is quite easy because the provided text is very simple and in a fairly commonplace context, the task is quite clear, and the set of three numbers in the advertisement is the only information that needs to be located and acted upon.

Level 2 Item

This item is based on two pie charts showing the percentage of the world population living in rural areas, urban areas with less than 1 million people and urban areas with more than 1 million people in two different years. Respondents are asked what percentage of the world population was living in urban areas in one specified year. This item is rather challenging for a number of reasons. The text includes pie charts with labels that must be carefully read in order to notice that data for two categories of urban areas are included. The task does not specify that the total urban population is required, so respondents must use the information in the pie charts to recognize that two percentages must be located and added. And the task-by-text feature that adds to the difficulty is the presence of distracting information, in that the same data is shown for two different years.

Level 3 Item

The final example is based on a table showing prices for concert tickets. In each of three seating categories, the prices for both a single concert ticket and a season ticket that includes six concerts are shown. The final category, student seating, shows only the price for a single concert ticket. Respondents are asked what the cost for a student season ticket would be, “using the same formula”. The formula for calculating the discount for season tickets is not provided. This is a difficult item both because respondents must recognize what the task requires (algebraic thinking and reasoning) and because the required multi-step calculations are rather complex.

Transitioning From Level 2 to Level 3 Numeracy Skills

Some of the key aspects related to the transition from Level 2 to Level 3 include developing the knowledge and skills to do the following:

- Reflect and work with more complex situations, including more formal mathematical contexts and more technical/dynamic representations, making judgements about how to use the given information
- Move from interpreting to interpreting and reasoning to solve presented problems
- Go beyond working in straightforward contexts to more complex contexts that are not always commonplace
- Progress to solving authentic numeracy problems where the situation or task, associated text and mathematical representation:
 - use more formal and complex terminology/ language and representation

- are embedded within a number of sources and are less explicit
- are located within a number of sources, often including distracting information.
- Solve problems where the tasks or questions are more open and require interpretation, where information outside the problem (prior knowledge) must be employed, where mathematical processes require the application of two or more different steps and where multiple criteria need to be satisfied and/or multiple sources may need to be accessed.
- Combine different operations in a multi-step line of reasonings and/or calculations, make more complex calculations (beyond basic arithmetic operations), measure objects to calculate area and volume, and use multiple sources for interpreting and reasoning with data sets to check statements.

Table 1 below summarizes the task complexity factors identified by the literacy and numeracy experts, with specific examples of key features in each domain.

Table 1. PIAAC Task Complexity Factors with Examples in Literacy and Numeracy

Complexity factors	Literacy	Numeracy
Text Features	Text length Topic novelty Number of sources	As per literacy, plus: Complexity of mathematical information/data (concrete vs abstract) Extent to which mathematical information is embedded in the text Use of informal versus formal mathematics terminology and representations
Task features	Question length and complexity Complexity of reading goals (number of targets and processing steps) Need to use text signals (e.g., headings) or navigation devices (scrolling, tabs on a website, etc.)	Question or directive length and complexity Determining whether and how best to represent the question or directive mathematically. Type and complexity of mathematical process, operation or skill required Expected number of mathematical operations or processes
Task-by-text features	Match between question and information in the text (locating information versus integrating information or drawing inferences) Need to connect distant pieces of information Dealing with distracting information	As per literacy, plus: Process(es) required to connect required action in the question to relevant mathematical information in the text

A Strategy for Developing Targeted Interventions

We believe that the existing frameworks and extensive analyses conducted by the literacy and numeracy experts and summarized in this paper can be leveraged to inform development of effective learning and assessment systems for various subpopulations of adult learners. This can be best achieved by integrating insights on the factors that influence task difficulty into a system design that includes:

- teaching learners to think critically about how information is organized (including both continuous and noncontinuous texts) and how that organization can make it easier or harder for them to accomplish a given task (see for example Mosenthal & Kirsch (1989-1991);
- identifying the kinds of strategies that can be used to access and use information so that learners can apply those strategies in a variety of contexts; and
- developing metacognitive skills such as approaching a task based on one's purpose and monitoring one's own comprehension or problem-solving process.

Such an approach is different from the ones traditionally used to teach reading and mathematics in schools and from the specific content knowledge typically taught in adult education programs (e.g., how to complete a specific job application or use an online train schedule). But we believe that linking the development of an instructional system to our understanding of what drives difficulty in the PIAAC assessment tasks is a desirable goal because, as we have noted elsewhere in the paper, the PIAAC frameworks and corresponding tasks for the literacy and numeracy assessments were developed by teams of international experts following the roadmap described in each of the framework papers. In addition, both the frameworks and the tasks were reviewed by the OECD and each of the 31 participating countries. As a result, the PIAAC tasks reflect a wide range of knowledge and skills that are required across a variety of adult contexts and have been shown to correlate with important social, educational and labor market outcomes (Fogg, et.al., 2018, 2022, 2023; OECD 2013; OECD 2024; Sands, et al., 2021).

We further believe that in order to create an effective learning and assessment system, a construct-based, evidence-centered design (ECD) approach should be employed. This method provides a structured roadmap for developing high-quality, coherent interventions that link learning objectives directly to measurable outcomes, helping ensure alignment between what is

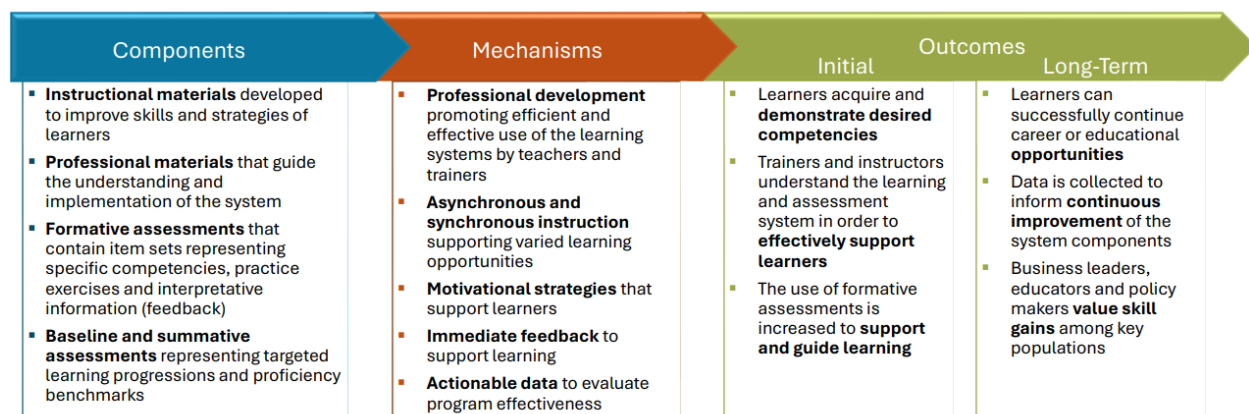
taught, how it is taught, and how progress is evaluated. This linkage not only facilitates consistent tracking of learner improvement but also serves to enhance motivation, as learners clearly see how their efforts align with measurable progress markers (See Chapelle *et.al.*, 2018; Hassrick *et.al.*, 2017; and Meirav *et.al.* for examples where this type of intervention has been used with various learner populations). To achieve this goal, a set of core integrated components should include the following:

- **instructional materials** designed to help adults in Level 2 develop important literacy and numeracy skills and strategies that promote their learning and ongoing skill development into Level 3 and beyond;
- **professional support materials** for trainers and instructors designed to both maximize successful implementation of the program and point to ways in which the instruction can be customized and delivered to best meet the needs of learners;
- **formative assessments** that can be developed and used throughout the program to monitor learning and reinforce learner engagement and success; and,
- **baseline and summative assessments** based on the PIAAC frameworks that can be used to: identify individuals who would most benefit from the instructional system, document the learning that has taken place, and offer a certificate to individuals who demonstrate proficiencies at Level 3 and higher.

In addition, Figure 1 presents a theory of action for such a system that includes action **mechanisms** through which the components could operate along with potential **initial** and **long-term outcomes** that would require validation as part of the development of any learning and assessment system.

An ideal system should be developed around an innovative, technology-based delivery platform that supports instructors and learners with nimble and flexible content and delivery options that involve synchronous, asynchronous, and blended approaches to instruction and learning. Further, instructors would need to be trained around key principles of the domain frameworks and critical components of the instructional approach so they can adapt and extend the formative assessments and practice materials to specific contexts that are of particular interest and importance to learners, including personal as well as job-specific settings and content.

Figure 1. Theory of Action: Evidence Centered Design (ECD) Learning and Assessment System



Further, it is our belief that any successful targeted intervention program aimed at improving adult literacy and numeracy skills needs to make sure that a set of appropriate features and practices such as those listed below are taken into account:

- the situational context in which the learning / training is taking place
- the importance of learner dispositions, attitudes and beliefs related to literacy and numeracy skills
- the need to be aware of previous learner experiences along with what counts as literacy and numeracy practices
- the variety of cognitive, meta-cognitive and non-cognitive knowledge and skills associated with workplace and everyday literacy and numeracy tasks
- the need to stress the important intersection between literacy and numeracy skills, including the role of understanding language as well as written and digital texts
- the need for explicit instruction involving comprehension/problem solving and reasoning skills when developing literacy and numeracy strategies, together with the use of modeling and guided practice
- the importance of providing opportunities for learners to communicate frequently about what they are learning
- in numeracy, the need to develop practical mathematical understanding and estimation skills by providing opportunities to explore mathematical ideas through hands-on, concrete and visual representations

Conclusion

Based on the PIAAC frameworks, the extensive analyses by the literacy and numeracy experts summarized here and the collective experience of the authors, we believe that select adults who demonstrate insufficient literacy or numeracy skills can be empowered through participation in high quality, targeted learning and assessment systems when these systems combine effective measurement and learning strategies with innovative technologies and insights to create a blended approach. Given the findings here and the more detailed findings in the two white papers that support this report, an *initial* strategy for such a system should focus on adults performing in Level 2 with the intention to increase their skills to Level 3. We recognize that developing and testing such a system would require research and development activities as well as support from interested providers and funders. Likewise, funding and support would also be needed to develop and implement a set of randomized controlled trials (RCT) to demonstrate the efficacy of this approach among various adult learner populations.

As AI and automation redefine the nature of work and everyday life, the interplay between technology and skills becomes increasingly consequential. While higher-order competencies such as problem-solving, critical thinking, and adaptability are widely regarded as essential for success, they rest on a foundation of literacy and numeracy—skills that remain unevenly distributed across adult populations. Findings from international assessments such as PIAAC make clear that significant portions of the workforce may struggle to navigate economies that demand the ability to engage with complex information. David Autor and others have suggested that AI has the potential to complement human labor and revitalize middle-skill jobs, but only for those with the requisite skills to use these tools. Without empirically based, targeted policies and interventions to strengthen skill development, technological progress risks deepening existing inequalities, further marginalizing those already at risk of being left behind. The challenge ahead is not just about the impact and proliferation of AI—it’s about ensuring that individuals have the skills to work alongside it. Our work here is meant to deepen our understanding about the skills adults need to support demands in the workplace and everyday life in our highly technological, digital world.

Appendix

Table A1. Main Features of the Literacy and Numeracy Assessment Frameworks, PIAAC Cycle 2

Feature	Literacy	Numeracy
Definition	Literacy is 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.	Numeracy is 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.
Cognitive processes	• Accessing text • Understanding • Evaluating	• Access and assess situations mathematically • Act on and use mathematics • Evaluate, critically reflect, make judgements
Content	Texts characterized by their: • Type (description, narration, exposition, argumentation, instruction, transaction) • Format (continuous, non-continuous, mixed) • Organization (the amount of information and the density of content representation and access devices) • Source (single vs. multiple texts)	• Mathematical content, information and ideas • Quantity and number • Space and shape • Change and relationships • Data and chance • Mathematical Representations • Text or symbols • Images of physical objects • Structured information • Dynamic applications
Contexts	• Work and occupation • Personal • Social and civic	• Personal • Work • Societal/community

Each assessment domain in PIAAC relies on the development of a *framework* document that is prepared by a group of 7-10 international experts that are nominated by the OECD and participating countries with the participation of the managing contractor, which for cycles 1 and 2 has been ETS. The development of these frameworks consists of several key steps. First, each expert group must define or adapt a definition of the construct, which in the case of literacy and

numeracy has changed over the previous decades and international assessments as the result of shifting technologies and the changing needs for different types of information and skills. Next, each definition is operationalized to reflect the range and types of tasks that must be developed or selected from previous assessments. These tasks provide the evidence needed to understand and interpret the results and typically reflect three key features associated with each domain: cognitive processes, content which is represented by the range of texts and representations, and the contexts or settings from which these materials are drawn. An overview of the main features described in the literacy and numeracy frameworks are shown below. In addition, each expert group prioritizes the emphasis given to these various features and then oversees the development and selection of the tasks for the field trial and main survey. It is worth noting here that these tasks are developed to represent a range of real-life tasks encountered by adults. Finally, each expert group helps guide the interpretation of the assessment results by identifying and discussing the factors that affect the difficulty of items and providing descriptions of the factors that may drive item complexity and difficulty. This final effort results in the development of brief descriptions of each of the six literacy and numeracy proficiency levels that are reported as part of the survey results (OECD, 2021).

Table A2. Conditional Probability of Correctly Answering Literacy Items at Different Difficulty Levels by Literacy Proficiency Scores¹⁶

Item difficulty level	Proficiency score for the Midpoint of each Level					
	150	200	250	300	350	400
Level 1	0.32	0.67	0.90	0.97	0.99	1.00
Level 2	0.24	0.45	0.67	0.83	0.93	0.97
Level 3	0.07	0.19	0.40	0.66	0.85	0.94
Level 4	0.00	0.02	0.07	0.26	0.61	0.88

Table A3. Conditional Probability of Correctly Answering Numeracy Items at Different Difficulty Levels by Numeracy Proficiency Scores

Item difficulty level	Proficiency score for the Midpoint of Each Level					
	150	200	250	300	350	400
Level 1	0.36	0.67	0.89	0.97	0.99	1.00
Level 2	0.05	0.26	0.68	0.93	0.99	1.00
Level 3	0.08	0.20	0.41	0.67	0.85	0.94
Level 4	0.04	0.10	0.23	0.43	0.66	0.84

Table A4. The Percentage of U.S. Adults in PIAAC Cycle 1 by Age Cohort and Proficiency Level

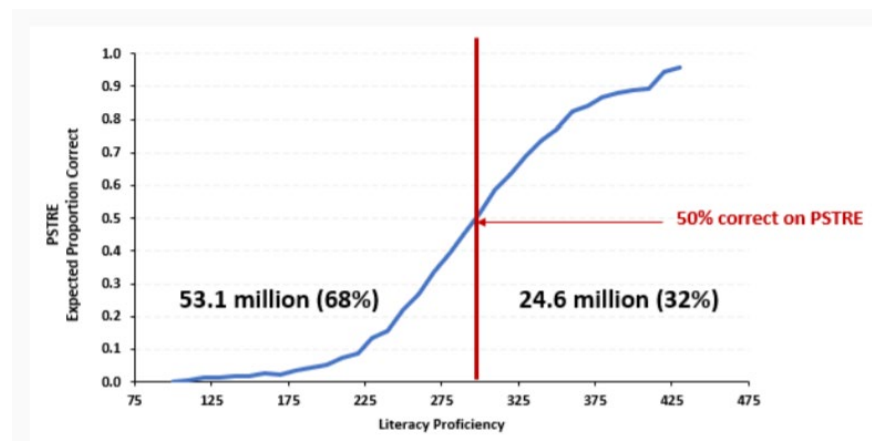
Proficiency level	16–24		25–54	
	Literacy	Numeracy	Literacy	Numeracy
Level 1 & Below	14	28	17	27
Level 2	37	37	31	32
Level 3	38	27	37	30
Levels 4/5	11	8	15	12

Proficiency level	Literacy		Numeracy	
	16–24	25–54	16–24	25–54
Level 1 & Below	14	17	28	27
Level 2	37	31	37	32
Level 3	38	37	27	30
Levels 4/5	11	15	8	12

Total number of young and prime working-age adults: Young Adults (16-24) = 37,110,630; Prime Working-Age Adults (25-54) = 119,659,725.

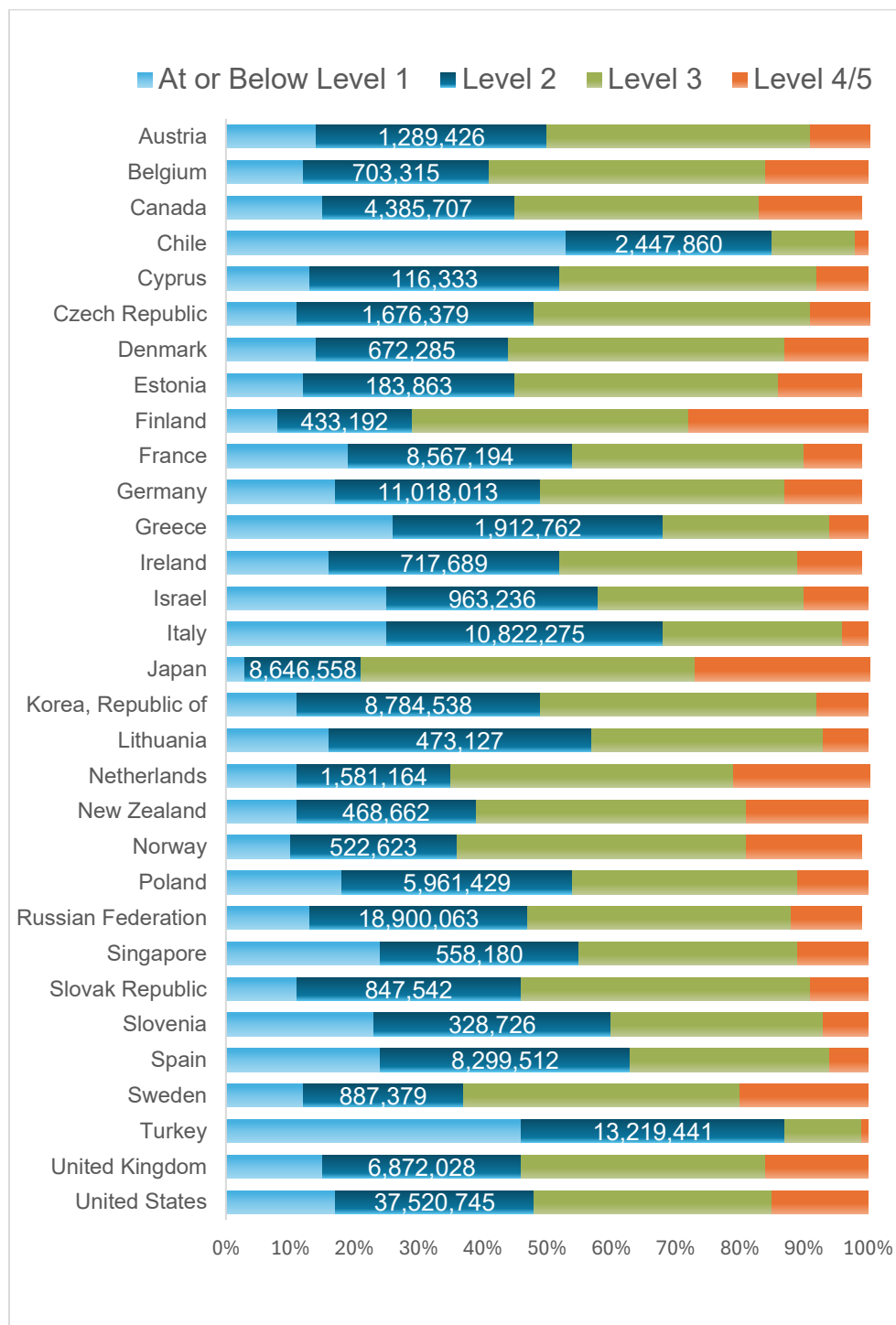
Source: Organisation for Economic Co-operation and Development (OECD), Programme for the International Assessment of Adult Competencies (PIAAC), Cycle 1 Restricted Use File, (2012/2014/2017).

Figure A1. Association of PIAAC Literacy Proficiency with Expected Scores on the Problem-Solving in Technology Rich Environments (PSTRE) Scale Among the U.S. Population Ages 16-34



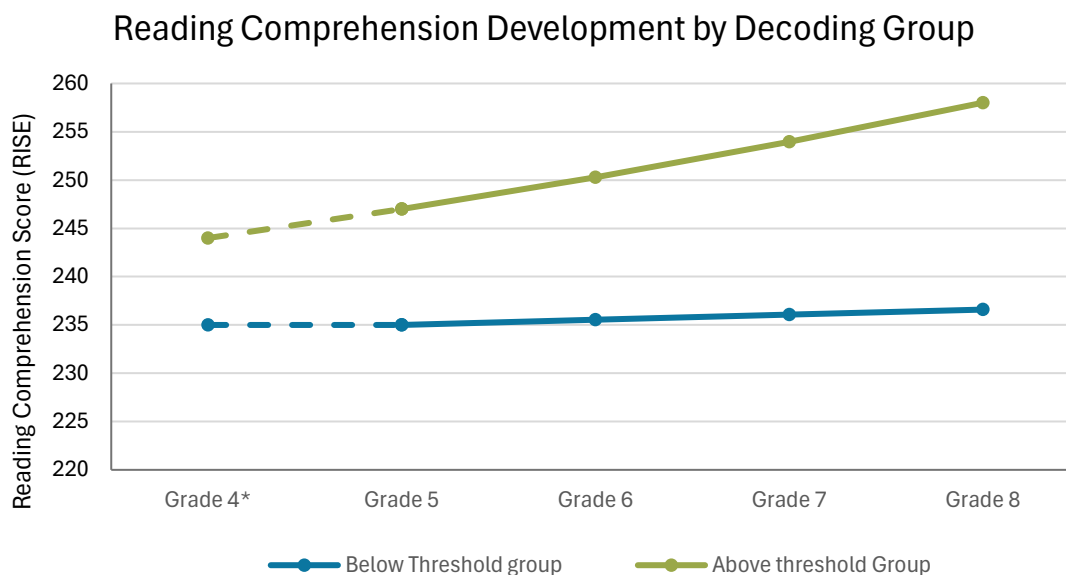
Source: Graphic prepared by authors using data from the Organisation for Economic Co-operation and Development (OECD), Programme for the International Assessment of Adult Competencies (PIAAC), 2012/2014.

Figure A2. The Percentages of the PIAAC Cycle 1 Prime Working-Age Populations by Country and Literacy Proficiency Level



Source : : Graphic prepared by authors using data from the Organisation for Economic Co-operation and Development (OECD), Programme for the International Assessment of Adult Competencies (PIAAC), Restricted Use File (2012/2014/2017), Cycle 1.

Figure A3. Average Change in Comprehension Scores by Grades Among Students Above and Below a Decoding Score Threshold



Source: Wang, Z., Sabatini, J., O'Reilly, T., & Weeks, J. (2019). *Decoding and reading comprehension: A test of the decoding threshold hypothesis*. *Journal of Educational Psychology*, 111(3), 387-401; Wang, Z., O'Reilly, T., & Sutherland, R. (2024). *Replicating decoding threshold in ReadBasix®: Impact on reading skills development* (Research Memorandum No. RM-24-06). ETS.

Note. Grade 4 data are extrapolated.

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Mary Louise Lennon (retired) served as a Research Project Manager with the Center for Global Assessment at Educational Testing Service (ETS). She worked on the development and implementation of cognitive instruments for a number of large-scale national and international surveys including the Programme for the International Assessment of Adult Competencies (PIAAC), the Programme for International Student Assessment (PISA), the Adult Literacy and Life Skills Survey, the International Adult Literacy Survey, and the National Adult Literacy Survey. As large-scale assessments moved to computer delivery, Ms. Lennon led development teams working on innovative computer-based assessments of ICT literacy, problem solving skills, scientific literacy and reading literacy. Ms. Lennon's additional ETS experience included working as a Development Scientist with the Research Division's Rapid Prototyping Lab. There

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Notes

¹ Since the second cycle of PIAAC is delivered on tablet, it is possible to extend the assessment to not only include digital and dynamic texts and representations but also to develop component measures of reading literacy and numeracy that better reflect some of the more basic, foundational tasks that are located mostly below level 1 and that are needed to support performance on more difficult tasks. For the literacy scale these include simple sentence and paragraph comprehension tasks while for numeracy they include simple number sense tasks. See the OECD 2021 PIAAC framework publication for more detailed information.

² The PIAAC literacy and numeracy scales range from 0-500 with the 6 levels divided as follows: Below Level 1, 0-175; Level 1, 176-225; Level 2, 226-275; Level 3, 276-325; Level 4, 326-375; and Level 5, 376-500.

³ Evidence to support this statement is presented in the section, Understanding and Using the PIAAC Frameworks to Interpret Results of this paper, under the subhead, Selected PIAAC Results.

⁴ Evidence-Centered Design (ECD) is a framework for developing educational assessments that ensures the collection and use of validity evidence from the start of the test design process. It focuses on clearly defining the knowledge and skills to be measured and systematically gathering evidence to support the inferences made from the assessment data.

⁵ For more information focusing on the proficiency scales developed in PIAAC please refer to the Technical Report for Cycle 1 (OECD 2019c), specifically see Chapters 2, 17 & 18 for a deeper discussion of the process used to develop the cognitive instruments as well as the procedures used to scale and understand the data

⁶ There are two types of evidence that support the connection to real world skills and knowledge: The first is that the materials or texts used in the development of the literacy and numeracy tasks are actual materials selected from everyday contexts and the questions or directives that were developed represent a variety of uses adults have for engaging with these materials. PIAAC participating countries were invited to participate in test development workshops so that they would better understand the development process. In addition, countries were invited to submit

materials and tasks from their national contexts. All cognitive tasks were submitted for national review by each participating country. The second type of evidence to support the relevance of the literacy and numeracy tasks in a real-world context is to examine how performance on these tasks relates broadly to differences in individuals' learning environments and access to educational opportunities, which is discussed further in this paper.

⁷ It is important to note that the literacy and numeracy scales used in Cycles 1 and 2 are statistically linked and therefore results are comparable. Although the experts did use the Cycle 2 items and their placement along each of the scales for their analyses we relied on the Cycle 1 results to discuss the percentage of adults in various levels and their connections to various outcomes. The primary reason for using Cycle 1 results is that a large body of research reports have been developed and published using the Cycle 1 data. Thus, we are able to cite references regarding not just the distributions of skills but also the connections of these skills to social, education, and labor market outcomes. The data for Cycle 2 are too recent for this type of work to have been completed and published.

⁸ IALS included measures of prose, document and quantitative literacy. Prose literacy focused on the assessment of skills required to use continuous texts and document literacy focused on non-continuous texts. The measure of quantitative literacy was narrower than the construct of numeracy included in PIAAC, focusing primarily on the skills required to apply arithmetic operations to tasks embedded in print materials.

⁹ Pilot studies were conducted in community-based programs, programs providing job skills training, two workplace sites, English as a Second Language (ESL) programs, and a prison-based education program.

¹⁰ Victorian Curriculum and Assessment Authority. (2021). VCE and VCAL Administrative Handbook 2021. Retrieved from <https://www.vcaa.vic.edu.au/Documents/handbook/2021/VCEVCALAdministrativeHandbook2021.pdf>

¹¹ See Victoria Curriculum and Assessment Authority, VCAL Assessment, <https://www.vcaa.vic.edu.au/assessment/vcal-assessment/Pages/Index.aspx>

¹² For those interested, the data are published by the Victorian Curriculum and Assessment Authority and are available at: <https://www.vcaa.vic.edu.au/administration/research-and-statistics/performance-senior-secondary/Pages/Index.aspx>

¹³ See working paper by the literacy expert group (Rouet et.al., 2024, in preparation) for a more thorough discussion of the literature around memory skills.

¹⁴ For more information about these two categories of materials see Mosenthal and Kirsch, 1989 – 1991.

¹⁵ Because inferences involve such a broad category of cognitive processes, it is difficult to identify precisely the skills that support them. An important distinction made by some researchers is the difference between connecting and elaborative inferences. Connecting inferences identify relationships among text segments such as the identification of a referent for a pronoun in a passage. Elaborative inferences, on the other hand, add information through the use of associations, computations, or informal reasoning. Whereas connective inferences do not require a lot of prior knowledge about the situation described in the text, elaborative inferences generally do.

¹⁶ Each row of Tables 2 represents the probability of getting a selected item from the midpoint of each Level on either the literacy or numeracy scale correct, while each column indicates the midpoint of each of the 6 proficiency levels from Below Level 1 through Levels 1-5. For example, on the literacy scale (top) looking at the row marked Level 2 and the column marked 250 (Midpoint Level 2) we can see that an individual scoring in the middle of Level 2 has a 67% chance of responding correctly to the corresponding literacy task. If we look up the column, we see they would have a 90% chance of responding correctly to a Level 1 task. Conversely, if we look down the column, we can see that their probability of responding to a Level 3 task is 40% and only 23% on a Level 4 task.

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