Coben, D., Miller-Reilly, B., Satherley, P., & Earle, D. (2016). Making the most of PIAAC: Preliminary investigation of adults' numeracy practices through secondary analysis of the PIAAC dataset. *Adults Learning Mathematics: An International Journal, 11*(2), 27-40

Making the most of PIAAC: Preliminary investigation of adults' numeracy practices through secondary analysis of the PIAAC dataset

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Abstract

The Programme for the International Assessment of Adult Competencies (PIAAC) assesses key information processing skills and collects information on how often people undertake a range of activities at work and in everyday life. We are exploring what secondary analysis of online anonymised PIAAC data can tell us about adults' numeracy practices. In the process we review the accessibility and user-friendliness of the data for novice researchers and practitioners in the hope of encouraging them to explore this rich resource and give a brief account of our experience of the process of accessing publicly-available PIAAC data for secondary analysis.

Key words: assessment, numeracy, adults, mathematics

In this paper we explore what secondary analysis of data from the latest international Survey of Adult Skills in the Programme for the International Assessment of Adult Skills (PIAAC[1]), can tell us about adults' numeracy practices. In the process we are also reviewing the accessibility and user-friendliness of the dataset. We hope to encourage the exploration of this rich resource by practitioners and researchers, including those with little previous experience of working with large datasets. This is important because, as Hansen and Vignoles(2007, p. 1) point out "In the last few decades, there has been an unprecedented increase in the availability and quality of large-scale data sets that are suitable for use in education research. Analyses of these data have the potential to radically improve the robustness and generalisability of educational research". In a still young but growing field such as adults learning mathematics, this is especially important.

We focus on secondary analysis of anonymised publicly-available PIAAC data. We draw our understanding of secondary analysis from Dale, Watham and Higgins (2008, p. 520): "Secondary analysis is generally understood as the analysis of data originally collected and analysed for another purpose". In addition, Heaton (1998) says "Secondary analysis involves the use of existing data, collected for the purposes of a prior study, in order to pursue a research

[1]http://www.oecd.org/site/piaac/surveyofadultskills.htm.

interest which is distinct from that of the original work; this may be a new research question or an alternative perspective on the original question". She adds that secondary analysis may be undertaken either by the original researchers or others.

The OECD has published two analytical reports on PIAAC (OECD, 2013a, 2016a). They relate to the first and second rounds of the PIAAC survey in participating countries. The New Zealand Ministries of Education, and Business, Innovation and Employment have published three initial reports: Ministry of Education & Ministry of Business, Innovation and Employment (2016a, 2016b, 2016c). Secondary PIAAC analysis will tackle research questions and topics beyond what is covered in the initial reporting, or take different or more in-depth approaches. Examples include:

- integrating different parts of the PIAAC dataset so as to generate new knowledge and understanding of associations and relationships
- building or refining conceptual or statistical models.
- exploring specific themes rather than taking a broad focus.

This paper explores an example of secondary analysis of numeracy practices in everyday life and work that takes a different perspective from the analysis of OECD (OECD, 2016a, pp. 97-113) which constructs indices that group together tasks involving similar activities.

What is PIAAC?

PIAAC is an international survey that assesses key information processing skills of adults of working age[2] in Literacy (reading) and Numeracy and collects information on how often they undertake a range of related activities in work and everyday life (OECD, 2013c). Two additional assessment components are optional for participating countries: Reading Components (Sabatini & Bruce, 2009); and Problem Solving in Technology-rich Environments (OECD, nd-b). PIAAC builds on previous international surveys: the 1994-1998 International Adult Literacy Survey (IALS) (OECD & Statistics Canada, 2000);and the 2003-2006 Adult Literacy and Life Skills Survey (ALL) (Satherley, Lawes, & Sok, 2008; Statistics Canada & OECD, 2005).

PIAAC is planned as a repeating survey with a ten-year cycle. The first cycle was undertaken in two rounds, with a third round scheduled for 2016-2019. Round One included 24 countries[3] with data collected in 2011/12 and findings published in 2013 (OECD, 2013a). New Zealand, together with eight other countries[4], participated in Round Two, with data collection April 2014 – February 2015. Results were released in June 2016 (OECD, 2016a).

Some key New Zealand findings are:

- New Zealand adults' literacy and problem solving skills are on average among the highest in the OECD
- New Zealand adults' numeracy skills are on average higher than the OECD average
- Although there are significant differences in skills between ethnic groups, average literacy and numeracy skills have been rising faster among Māori and Pasifika than in the total New Zealand population

[2] Normally 16-65 years but this can vary, e.g., Australia extended the range to 15-74 years.
[3]Round 1 PIAAC countries were: Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, The Netherlands, Norway, Poland, Russian Federation, Slovak Republic, Spain, Sweden, United Kingdom, the United States.
[4]Round 2 PIAAC countries were: Chile, Greece, Indonesia, Israel, Lithuania, New Zealand, Singapore, Slovenia, and Turkey. Round 3 PIAAC countries will be: Argentina, Colombia, Hungary, Kazakhstan, Mexico, Peru and the United States of America (the latter repeating PIAAC in subpopulations).

- Overseas-born New Zealanders have on average higher literacy and numeracy scores than overseas-born people in any other country
- While there are no differences in average literacy and problem solving skills between men and women, men have higher numeracy skills on average than women.

The PIAAC survey is carried out by: interviewing a sample of at least 5000 adults in each participating country[5] in their homes; collecting a broad range of information through a Background Questionnaire[6]; and assessing skills in the PIAAC domains. The language of assessment is normally the official language or languages of each participating country[7]. Depending on their computer skills[8], participants either enter their responses to the assessment items of the main skill domains on the assessor's laptop computer or complete a paper version using printed test booklets. The Background Questionnaire is administered face-to-face in the respondent's home by an interviewer who enters the answers into a laptop computer. All aspects of countries' implementation of PIAAC is strictly monitored and quality-assured by the PIAAC Consortium. PIAAC governance is provided by a Board of Participating Countries.

The Background Questionnaire collects data on participants' educational background, skills used at work (for those currently or recently in employment) and in other contexts such as the home and the community. For example, people are asked about their voting habits, volunteering, languages spoken, political efficacy and health. The following variables are covered: demographic characteristics; other personal characteristics (including learning disposition and self-assessed health status); education and training characteristics; work characteristics; self-assessed mathematics skills for work; self-assessed reading and writing skills for work; and skill use in everyday life.

Respondents with very low literacy skills (as assessed by some initial questions) are not assessed in the main skill domains, but instead go directly to the Reading Components assessment. This covers "the basic set of decoding skills that enable individuals to extract meaning from written texts: knowledge of vocabulary, ability to process meaning at the level of the sentence, and fluency in reading passages of text" (OECD, nd-a, p. 1).

In PIAAC, proficiency is considered as a continuum of ability involving information-processing tasks of increasing complexity defined as 'proficiency levels' (OECD, 2013b, p. 64). Six proficiency levels are described for Literacy and Numeracy (Levels 1 to 5, and below Level 1) and four for Problem Solving in Technology-rich Environments (Levels 1 to 3, and below Level 1). These summarise what adults with proficiency scores in each skill domain can do. The 'average' individual with a proficiency score in the range defining a level will successfully complete items located at that level approximately two-thirds of the time. PIAAC measures cognitive skills through test items that have a range of contexts: work-related, personal, society and community, and education and training. The OECD has released a number of sample test items (OECD, 2016b, pp. 21-23; 26-28; 31-32). The work context of PIAAC's cognitive skill assessment is complemented by self-reports on generic skills required in work, including inter-personal skills and physical skills.

As for earlier international skill surveys, PIAAC published results include: average scores on each skill domain for countries and population subgroups; comparisons over time and with other countries; and proportions of different sub-populations reaching different benchmarks for each skill domain.

[5]Participating countries can increase the sample size to provide better information on specific sub-populations; e.g., New Zealand oversampled 16-25 year olds and Māori.
[6] The PIAAC Background Questionnaire is at http://www.oecd.org/site/piaac/BQ_MASTER.HTM.
[7] In some countries, PIAAC assessment has also been conducted in widely-spoken minority or regional languages.
[8] Problem Solving in Technology-rich Environments is assessed only on a computer, so only participants who have sufficient computer skills and choose to use a computer are assessed on this domain.

PIAAC breaks new ground by: expanding the range of skill domains measured; including information on the skills of adults with levels of proficiency below Level 1; expanding the self-reported measures of the use of skills at work; introducing self-reported measures of qualifications matched to work; using computers to administer this kind of international assessment; making data publicly available for review and secondary analysis on an unprecedented scale via the PIAAC website[9]; having an online version of the assessment publicly available[10]; and not specifying Level 3 as a benchmark (OECD, 2010, p. 4).In IALS, Level 3 was considered to be the minimum skill level required to cope with the demands of modern society (OECD & Statistics Canada, 2000, p. xi). However, while many higher-level jobs require Level 3 or above, there is no evidence that everyone needs to be at Level 3. This change is significant because, as Black and Yasukawa (2014) point out, the Level 3 criterion has been used by powerful institutions to promote a crisis discourse in adult literacy and numeracy.

For more detail about PIAAC constructs, methods and how the survey was undertaken in participating countries, see the PIAAC *Reader's Companion*(OECD, 2016b).

Numeracy in PIAAC

Numeracy[11] is defined in PIAAC as:

> the ability to access, use, interpret and communicate mathematical information and ideas in order to engage in and manage the mathematical demands of a range of situations in adult life … Numerate behaviour involves managing a situation or solving a problem in a real context, by responding to mathematical content/information/ideas represented in multiple ways. (OECD, 2012, p. 34)

PIAAC directly measures numeracy proficiency through the Numeracy assessment. This provides average scores on the PIAAC Numeracy scale for the whole population, or for subgroups.

PIAAC also collects numeracy-related information via the Background Questionnaire. The interviewer asks respondents how often they undertake seven[12] numeracy practices in work (if appropriate)[13] and everyday life. For example:

> The following questions are about activities that you undertake as part of your job and that involve numbers, quantities, numerical information, statistics or mathematics.
>
> - In your job, how often do you usually calculate prices, costs or budgets?
> - Use or calculate fractions, decimals or percentages?
> - Use a calculator – either hand-held or computer based?
> - Prepare charts, graphs or tables?
> - Use simple algebra or formulas?
> - Use more advanced mathematics or statistics such as calculus, complex algebra, trigonometry, or use of regression techniques?

[9]http://www.oecd.org/site/piaac/publicdataandanalysis.htm
[10]A public online version of the PIAAC survey is at http://www.oecd.org/skills/ESonline-assessment/.
[11]The Numeracy domain in the ALL survey is comparable with the Numeracy domain in PIAAC but not with the Quantitative Literacy domain in IALS.
[12]The international version of the PIAAC Background Questionnaire includes the first six of these numeracy activities. New Zealand asked for the seventh activity, 'measure or estimate the size or weight of objects', to be added as a national extension. This activity was in the 2006 ALL survey and it was found to be analytically useful as it helps identify groups of people whose numeracy activities have this simple practical purpose.
[13]The same questions are asked in the past tense for people who are not currently working, but who worked in the last 12 months.

- Measure or estimate the size or weight of objects?

The frequency options are: *Never; Less than once a month; Less than once a week but at least once a month; At least once a week but not every day; Every day*. These data provide measures of the frequency and diversity of participants' numeracy activities. The activities can be analysed separately, or a range of options can be developed for deriving an index of numeracy activity by combining the data across the activities.

The Adult Literacy and Life Skills Survey (ALL) asked similar questions, and since analysis of these questions, together with occupational characteristics, provided a coherent picture, we have some good assurance of the validity of these measures (Satherley, Lawes, & Sok, 2009).

Analysing adults' numeracy practices: issues and types of analysis

A range of types of analysis may be used to explore questions about adults' numeracy practices[14]. Simple univariate tabulations can provide a 'big picture' view while multivariate analysis such as multiple regression can provide measures of the contributions of different factors to associations with numeracy practice. For example, frequent practice of numeracy activities at work may be associated with: higher levels of education; numeracy-related fields of study; specific groups of occupations; and higher measured numeracy skill. Such analysis can show which factors are most strongly associated with frequent numeracy practice and how much increase in frequency of numeracy practice is associated with one unit of measured numeracy skill, whilst holding other factors constant.

PIAAC data cannot tell us to what extent frequent numeracy practicecauses high numeracy skill, so researchers should not use ambiguous language such as 'leads to', 'brings about', 'influences', or 'is linked with'. In any case, it may be that numeracy practice, opportunity or requirement to undertake numeracy practice, and numeracy skill are all mutually reinforcing. Even where data show a strong association between two factors (for example, numeracy practice and numeracy skill) whilst controlling for other factors, we cannot infer that a change in one factor will result in a change in the other, either on an individual or a group level. Another limitation is that PIAAC does not provide a measure of either the intensity or complexity of numeracy activity. For example, finance analysts doing nothing but calculating costs and budgets would report the same way as someone who worked on costs and budgets for 10 minutes every day. Researchers also need to be aware of issues relating to continuous and categorical variables. For example, PIAAC frequency options are five separate categories, although for some analytical purposes it may be legitimate and useful to derive a continuous frequency variable from the discrete categories.

Some other methodological or technical issues users should be aware of include:

- The 2016 PIAAC report (OECD, 2016a) presents OECD averages based on the 28 OECD countries participating in Round 1 or Round 2. This differs from the averages presented in (OECD, 2013a) based only on Round 1 countries.
- Numeracy skill is directly measured, whereas participation in numeracy activities is self-reported.
- The PIAAC data are rich enough to provide scope for different indicators of a construct, such as job-skill mismatch. What indicator is the most useful will depend on the purpose of the analysis, or the need for comparability with published findings across countries.

[14]We recommend novice researchers should consult a text book covering quantitative research methods in the social sciences (e.g., De Vaus, 2014; Frankfort-Nachmias, Nachmias, & DeWaard, 2015).

- Where a user analyses PIAAC data across all or many participating countries, the large sample may mean that nearly all differences are statistically significant. This will not apply for an analysis for one or a few countries, and very fine analysis with many variables for a single country may entail large sampling errors and therefore few significant differences.

Some questions about numeracy activities that PIAAC secondary analysis can help answer

In this section we pose some questions to demonstrate the process we went through in our exploration of the PIAAC dataset and comment on how these questions could be answered through secondary analysis of the PIAAC data. The OECD has published an initial analysis of skill use at work and in everyday life (OECD, 2016a, pp. 98-100). This is a country comparison that aggregates activities and summarises frequencies into an index. Our paper aims to suggest more in-depth and more detailed analysis focused on more specific research questions beyond that of the OECD report.

How often do people perform numeracy activities at work and in everyday life?

PIAAC numeracy activities at work and in everyday life and frequency categories can be shown in tables as simple frequency tables, i.e., activity categories can denote rows with frequency categories, denoting columns[15].

What are the patterns for different groups in numeracy activities at work?

The PIAAC Background Questionnaire sheds light on the part numeracy activities play in different kinds of work for different groups of people. PIAAC classifies *Occupations*[16] as: *Managers*; *Professionals*; *Technicians; Clerical*; *Service & sales*; *Agriculture & fisheries workers*; *Trades*; *Machine workers*; and *Labourers*. Even at this broad level, analysis of the 2006 New Zealand ALL data show distinct profiles of numeracy activity for different occupations, for example, managers, trades workers, technicians, professionals, and agriculture and fisheries workers engaged in relatively frequent numeracy practice compared to clerical, labourers, machine and service and sales workers (Satherley et al., 2009). Broad PIAAC *Industry sector* groups include: *Agriculture & fisheries*; *Manufacturing*; *Construction*; *Trade*; *Transport & communications*; *Finance & real estate*; and *Health & education*. Analysis of PIAAC data will enable researchers to identify sectors with unexpected pockets of high or low numeracy activity. We can also look at the association between numeracy practice and measured numeracy skill to answer questions such as:

- How likely are people with strong numeracy skill to have jobs that entail frequent numeracy activity?
- Where in the economy do we see areas of job-skill mismatch? One way of tackling this question is developing an indicator of job-skill match that compares actual numeracy skill with the frequency of undertaking numeracy activities. A possibility is grouping respondents into (a) high, medium and low numeracy skill and (b) high, medium and low frequency of undertaking numeracy activities at work; then derive a third grouping: over-skilled, under-skilled and matched; then we could investigate industry or occupation patterns for this indicator (see OECD, 2016a, pp. 129-143).

Analysis by socio-demographic characteristics can also show different numeracy activity patterns for different groups by: gender; age group; education level; and field of study. New Zealand's oversampling of 16-25 year olds and Māori will allow these groups' numeracy activities to be examined in detail.

[15] See Cross Tabulation Analysis: https://www.qualtrics.com/wp-content/uploads/2013/05/Cross-Tabulation-Theory.pdf

[16] PIAAC dataset categories and sub-categories are italicised for ease of reference.

What are the patterns for different groups for numeracy activities in everyday life?

We can analyse numeracy activities in everyday life similarly to work contexts. In this case analysis is likely to focus on socio-demographic characteristics and measured numeracy skill.

What similarities or differences exist for numeracy activity at work and in everyday life?

By looking at participants' numeracy activities at work and in everyday life, we may discern patterns of global differences between these two contexts for individuals. For example, if we were interested in calculator use in work compared to in everyday life, we could cross-tabulate these variables.

What similarities or differences exist for numeracy and literacy activity at work?

Literacy activities at work included in the Background Questionnaire cover eight reading and four writing activities: *Read directions or instructions; Read letters, memos or emails; Read articles in newspapers, magazines or newsletters; Read articles in professional journals or scholarly publications; Read books; Read manuals or reference materials; Read bills, invoices, bank statements or other financial statements; Read diagrams, maps or schematics; Write letters, memos or emails; Write articles for newspapers, magazines or newsletters; Write reports;* and *Fill in forms*. One approach to making sense of this level of detail is to summarise the numeracy activities by creating a frequency index. For example, we could assign a numerical code for the frequency options and add the codes to obtain a total score, which would be a measure of the frequency and diversity of numeracy activities undertaken. Someone with a high score often engages in several different numeracy activities. We could generate similar indices for reading and/or writing. This would allow us to study the characteristics of, for example, people who score highly on both numeracy and literacy activities at work.

What similarities or differences exist for numeracy and literacy activity in everyday life?

We could take a similar approach to explore numeracy and literacy activity in everyday life. For example, we could look at questions about whether numeracy and literacy activities in everyday life go together for many people or not. What are the characteristics associated with undertaking a lot of different numeracy and literacy activities? Can we identify characteristics that are associated with seldom undertaking few numeracy and literacy activities?

What can PIAAC tell us about adults' financial capability?

PIAAC can shed light on financial capability, for example, through a study of the relationships between directly measured numeracy skill and the self-reported numeracy activity of calculating prices, costs or budgets. Similarly we could study literacy skill and the literacy activity of reading bills, invoices, bank statements or other financial statements. Acknowledging that numeracy activity is self-reported, inferences about financial literacy skill may still be possible.

What are the patterns of work-related numeracy activity together with ICT activities?

The PIAAC Background Questionnaire asks how often people participate in the following ICT activities: use email; use the internet in order to better understand issues related to your work; conduct transactions on the internet; use spreadsheet software; use a word processor; use a programming language to program or write computer code; participate in real-time discussions on the internet. These could be analysed using a similar approach to the comparisons between numeracy and literacy activities.

What are the characteristics of people who seem to be matched or mismatched on numeracy skill at work and numeracy activity? Are Field of study of highest qualification, or Occupation related to the match or mismatch?

To what extent people's numeracy skill aligns with their numeracy activity is an important issue. A working-age population might contain significant proportions who could easily manage more

(or a higher level of) numeracy activity than they actually engage in, or significant proportions who are attempting numeracy activity that their skills do not support. In these cases, a work skills policy issue seems to emerge about whether policy levers should be applied to support a more efficient allocation of numeracy skills and numeracy activity.

One approach to better understanding numeracy skill and activity mismatch would be a multivariate analysis of *Numeracy activity*, *Measured numeracy skill*, and *Main field of study of highest qualification*, and *Occupation*. This could build on an OECD report on the first round of PIAAC entitled The System-level Causes and Consequences of Field-of-study Mismatch (Montt, 2015).

What changing patterns for young people's numeracy activities can we see on their pathways from school to tertiary education to work?

Here we could identify subgroups of 16-25 year olds who are: at school; in formal tertiary education; in full-time work; or combining work with study. We could identify what characteristics are strongly associated with participating in numeracy activities in everyday life (including study). These could include respondents': age; gender; level of highest qualification; the level of qualification they are studying for; the main subject of qualification they are studying for; the type of educational institution they are studying at; whether they are also undertaking non-formal or informal study; and their occupation and numeracy activities at work (for those currently or recently working).

How have patterns of numeracy activity at work changed over time?

The ALL survey asked how often people participated in six numeracy activities as part of their job. The ALL activities were: *Measure or estimate the size or weight of objects; Calculate prices, costs or budgets;Count or read numbers to keep track of things; Manage time or prepare timetables; Give or follow directions or use maps or street directories;* and *Use statistical data to reach conclusions*. The first two on the above list of activities were re-asked, the first in New Zealand's PIAAC survey only, and the second internationally. Using these data, we could look at how often workers undertook the numeracy activities in common between ALL and PIAAC, and investigate whether changes over time are associated, for example, with changing work, with changing occupational composition, or changing levels of education.

We turn now to a brief account of our experience of the process of accessing publicly-available PIAAC data for secondary analysis.

Using PIAAC Data Explorer to access PIAAC data

Information on PIAAC *Public Data & Analysis* is available online[17]. The OECD PIAAC Gateway website *Data Tools › Datasets and Tools*[18] is designed to give users the tools needed to analyse the PIAAC dataset. The ***Data Tools*** section provides information on how to analyse a chosen dataset and ***Data Files*** are available, categorised as *National*, *International*, and *Trend*. Users are advised to read the guide *What You Need to Consider*(AIR PIAAC Team, nd) and watch online Distance Learning Data Training (DLDT) modules[19] to learn about appropriate statistical procedures and methods of analysis before accessing the PIAAC datasets. Users may also wish to consult a survey statistician or a psychometric expert for technical advice.

The PIAAC International Data Explorer (IDE)[20] is a web-based application for accessing PIAAC data that does not require any advanced statistical knowledge or specialist software. It is a point-and-click interface for creating statistical tables and charts and exploring levels of adult skills and demographics.

[17]http://www.oecd.org/site/piaac/publicdataandanalysis.htm
[18]http://piaacgateway.com/datasets/
[19]http://nces.ed.gov/training/datauser/#PIAAC
[20]http://piaacdataexplorer.oecd.org/ide/idepiaac/variables.aspx

There are four steps to progress through when using the PIAAC Data Explorer, supported by the DLDT modules. We outline our journey through the process as follows.

Step 1

In the first step we chose a *Subject* (*Numeracy*) from three options: *Literacy*; *Numeracy*; and *Problem Solving in Technology-rich Environments*. Note that *Adults (16-65)* is the only option for *Age* at this point. After the choice of *Numeracy*, a fuller screen appears. Initially there is a choice of which Background Questionnaire dataset to use: *PIAAC 2012*, *ALL 2003* or *All years/studies*; we chose *PIAAC 2012*.

Next we selected a dependent variable from the 72 Categories and Groups available. Then we selected a jurisdiction or group from the 20 national and 17 sub-national entities available, as well as the OECD average. Under the Category *Scale Scores*, and Sub-Category *Skills*, the Measure *PIAAC Numeric: Numeracy* is already selected. Under the Group *International*, we chose the jurisdiction *OECD average*. We clicked on *Select Variables* to move to Step 2.

Step 2

At Step 2, we selected independent variables (from a choice of 334) in order to examine the strength of associations between these and the dependent variable chosen above. Under the Category (and Sub-Category) *Major reporting group* we chose the variable *All Adults*. In addition, under the Category *International Background Questionnaire*, and Sub-Category *Skill use – literacy & numeracy*, we chose the following six variables:

- *Skill use work - Numeracy - How often - Calculating costs or budgets*
- *Skill use work - Numeracy - How often - Use or calculate fractions or percentages*
- *Skill use work - Numeracy - How often - Use a calculator*
- *Skill use work - Numeracy - How often - Prepare charts graphs or tables*
- *Skill use work - Numeracy - How often - Use simple algebra or formulas*
- *Skill use work - Numeracy - How often - Use advanced math or statistics*

We then clicked on *Edit Reports* to move to Step 3.

Step 3

Step 3 allowed us to choose the types of statistics we wanted to report, collapse any variable response categories, adjust table layouts and refine the formatting of the reports to be generated, using the variables chosen above. To summarize, we trialled the use of the PIAAC International Data Explorer (PIAAC IDE)[21] by exploring information about the percentage of adults currently or recently in work who self-report the frequency of their engagement in given numeracy practices in their work contexts, and their average Numeracy scale scores for each category. We focused on the PIAAC jurisdiction *OECD average*, then chose as variables *Skill use work* for each of the six specified numeracy skills in order to generate the average PIAAC Numeracy scale scores and the percentages of adults aged 16-65 in each usage response (frequency) category.

[21] http://piaacdataexplorer.oecd.org

The PIAAC International Data Explorer generated seven draft reports. These seven reports can be reviewed, edited, deleted or copied. New reports can be created, new formats and statistics chosen. We selected *Averages and Percentages* from the drop-down menu *Statistics Options*.

We clicked on *Build Reports* to move to Step 4 to view the completed reports.

Step 4

At the fourth step PIAAC IDE generated a report for each of the six variables of *Numeracy skill use at work*. Each report lists *Averages* of the Numeracy scale scores and *Percentages* of the population (each with Standard Errors) for the response categories: *Never; Less than once a month; Less than once a week but at least once a month; At least once a week but not every day; Every day*. Each report table can be viewed by selecting the report name from the drop-down menu. At this stage, we could preview and select information displayed in these tables or charts.

In addition, PIAAC IDE will generate (on request) comparisons between frequencies of skill use with significance tests for each of the six variables (*Numeracy skill use at work*) for the statistic specified. This allowed us to compare, for example, the means of two frequency groups to see if the difference is statistically significant. For this trial run we requested these significance tests be generated for each numeracy skill for both percentages and averages. Our use of large samples will mean that almost all differences will be statistically significant. (This issue is discussed in the section above entitled "Analysing adult numeracy practices: issues and types of analyses"). Our purpose in this instance was to examine the tables that would be generated by PIAAC IDE.

We then chose *Export reports* and downloaded our selected reports as Excel worksheets, allowing us to manipulate the data generated. Tables 1, 2 and 3, below, were produced through such a reorganisation of these Excel original reports/tables. At this stage we could have chosen instead to download the reports as HTML or Word documents.

The first six reports, one for each of the six variables of *Numeracy skill use at work,* are summarised in Table 1 (below).

Table 1

Average Numeracy scale scores and percentage of adults for frequency options for Numeracy skill use at work *variables*[22]

		Never				Less than once a month				Less than once a week but at least once a month				At least once a week but not every day				Every day			
Year/Study	Jurisdiction	Avge	Std error	Per-cent	Std error	Avge	Std error	Per-cent	Std error	Avge	Std error	Per-cent	Std error	Avge	Std error	Per-cent	Std error	Avge	Std error	Per-cent	Std error
Average of Numeracy scale scores and Percentage of adults by Frequency of Calculating costs or budgets in a work context																					
2012	OECD Average	264	(0.3)	49	(0.2)	289	(0.6)	10	(0.1)	290	(0.7)	8	(0.1)	286	(0.5)	11	(0.1)	280	(0.4)	21	(0.1)
Average of Numeracy scale scores and Percentage of adults by Frequency of Use, or calculations of, fractions or percentages in work context																					
2012	OECD Average	257	(0.3)	46	(0.2)	283	(0.6)	9	(0.1)	291	(0.6)	8	(0.1)	293	(0.5)	13	(0.1)	290	(0.4)	23	(0.2)
Average of Numeracy scale scores and Percentage of adults by Frequency of Use of a calculator in a work context																					
2012	OECD Average	254	(0.4)	30	(0.2)	278	(0.7)	8	(0.1)	284	(0.7)	8	(0.1)	286	(0.5)	17	(0.1)	283	(0.3)	37	(0.2)
Average of Numeracy scale scores and Percentage of adults by Frequency of Preparation of charts, graphs or tables in a work context																					
2012	OECD Average	261	(0.3)	60	(0.2)	290	(0.5)	13	(0.1)	298	(0.5)	10	(0.1)	300	(0.6)	10	(0.1)	294	(0.8)	6	(0.1)
Average of Numeracy scale scores and Percentage of adults by Frequency of Use of simple algebra or formulas in a work context																					
2012	OECD Average	260	(0.3)	55	(0.2)	290	(0.6)	9	(0.1)	296	(0.7)	7	(0.1)	297	(0.6)	11	(0.1)	292	(0.5)	17	(0.1)
Average of Numeracy scale scores and Percentage of adults by Frequency of Use of advanced math or statistics in a work context																					
2012	OECD Average	270	(0.2)	86	(0.1)	303	(0.7)	7	(0.1)	306	(1.0)	3	(0.1)	305	(1.2)	2	(0.1)	297	(1.4)	2	(0.0)

NOTE: The Numeracy scale ranges from 0 to 500. Some apparent differences between estimates may not be statistically significant.
Average (Avge); Percentage (Percent); Standard Error (std error).
SOURCE: Organization for Economic Cooperation and Development (OECD),
Program for the International Assessment of Adult Competencies (PIAAC), 2012.
Reports used for this table were generated using the PIAAC International Data Explorer. http://piaacdataexplorer.oecd.org

[22]The data used were the *OECD Average* for *PIAAC 2012*.

Looking at percentages in Table 1 across the six *Numeracy skill use at work* variables (rather than within each skill), we found that the percentages of adults responding *Never*with regard to the category, *Numeracy skill use at work - Use a calculator* was the lowest (30%) (of all the six numeracy skills) and the percentages of adults in the response category *Every day* was the highest (37%) (of all six skills). The use of calculators in the workplace therefore emerges as very common, since less than one third of adults in, or recently in, work indicate that they never use them at work.

The next similar frequency response pattern is *Use or calculate fractions or percentages* with 46% indicating *Never* and 23% indicating *Every day*, although *Calculating costs or budgets* is similar, with 49% and 21% respectively in these response categories. In other words, almost one half of adults in, or recently in, work reported that they never used these two numeracy skills at work. Focusing on averages across the six *Numeracy skill use at work* variables (rather than within each skill), we found that the averages of Numeracy scale scores within the frequency option *Never* are the lowest (of all frequency categories) for all six skills. These percentages and averages for the less complex Numeracy skills may indicate that adults with the lowest numeracy skill are choosing to work in jobs that entail infrequent numeracy activity. Equally it may indicate the converse – employers may recruit staff in a way that closely matches skills to the job, or infrequent numeracy practice may lead to skill loss. If the latter, this would support the findings of research on the British Cohort Studies that showed adults' skills diminishing with lack of use (Bynner & Parsons, 1998, 2000).

For the more complex numeracy skills, *Numeracy skill use at work - Use advanced math or statistics* shows percentages of adults in the response category *Never* as the highest (86%) (of all six skills) and percentages of adults in the response category *Every day* as the lowest (2%) (of all six skills). The next similar (but less striking) skill response pattern is *Prepare charts graphs or tables*, with 60% indicating *Never* and 6% indicating *Every day*, although *Use simple algebra or formulas* is similar, with 55% and 17% in these response categories respectively. Averages of numeracy scale scores for *Numeracy skill use at work - Use advanced math or statistics* are somewhat higher within most response categories. These percentages and averages may suggest that people with strong numeracy skills have jobs that entail frequent numeracy activity.

Table 2

Frequency of use of a calculator in a work context. Significance tests of the differences between either percentages or averages, calculated for each of the five frequency options

Difference in percentages between variables

	Never	Less than once a month	Less than once a week but at least once a month	At least once a week but not every day	Every day
Never		> Diff = 22 P-value = 0	> Diff = 21 P-value = 0	> Diff = 13 P-value = 0	< Diff = -7 P-value = 0
Less than once a month	< Diff = -22 P-value = 0		< Diff = -1 P-value = 0	< Diff = -9 P-value = 0	< Diff = -29 P-value = 0
Less than once a week but at least once a month	< Diff = -21 P-value = 0	> Diff = 1 P-value = 0		< Diff = -9 P-value = 0	< Diff = -28 P-value = 0
At least once a week but not every day	< Diff = -13 P-value = 0	> Diff = 9 P-value = 0	> Diff = 9 P-value = 0		< Diff = -20 P-value = 0
Every day	> Diff = 7 P-value = 0	> Diff = 29 P-value = 0	> Diff = 28 P-value = 0	> Diff = 20 P-value = 0	

Difference in averages between variables

	Never	Less than once a month	Less than once a week but at least once a month	At least once a week but not every day	Every day
Never		< Diff = -24 P-value = 0	< Diff = -30 P-value = 0	< Diff = -32 P-value = 0	< Diff = -29 P-value = 0
Less than once a month	> Diff = 24 P-value = 0		< Diff = -6 P-value = 0	< Diff = -8 P-value = 0	< Diff = -5 P-value = 0
Less than once a week but at least once a month	> Diff = 30 P-value = 0	> Diff = 6 P-value = 0		< Diff = -2 P-value = 0.0245	x Diff = 1 P-value = 0.2616
At least once a week but not every day	> Diff = 32 P-value = 0	> Diff = 8 P-value = 0	> Diff = 2 P-value = 0.0245		> Diff = 3 P-value = 0
Every day	> Diff = 29 P-value = 0	> Diff = 5 P-value = 0	x Diff = -1 P-value = 0.2616	< Diff = -3 P-value = 0	

LEGEND:

<	Significantly lower.
>	Significantly higher.
x	No significant difference.

NOTE: Within country comparisons on any given year are dependent with an alpha level of 0.05.

OECD Average, PIAAC 2012
Organization for Economic Cooperation and Development (OECD)
Program for the International Assessment of Adult Competencies (PIAAC)

Generated using the PIAAC International Data Explorer.

Examples of the types of reports generated by PIAAC IDE in the form of tables of differences between percentages and averages, with associated p-values[23]are shown in Tables 2 and 3, below, for two numeracy skills (percentages and averages are combined).

To see how one percentage (or average) compares with those for other frequencies, users should read across the row for that value in Tables 2 and 3. The displayed symbols indicate whether that value is significantly higher, significantly lower, or not significantly different from the value associated with that column.The p-value indicates the probability with which a difference in percentages (or averages) between frequency groups as large as observed here could occur by chance, if there were actually no difference. The customary significance level is 5% (0.05). The p-value must fall under this significance level for the results to be deemed statistically significant. As expected, most differences were statistically significant with very low p-values.

Table 3

Frequency of preparation of charts, graphs or tables in a work context. Significance tests of the differences between either percentages or averages, calculated for each of the five frequency options

Difference in percentages between variables

	Never	Less than once a month	Less than once a week but at least once a month	At least once a week but not every day	Every day
Never		> Diff = 48 P-value = 0	> Diff = 50 P-value = 0	> Diff = 50 P-value = 0	> Diff = 54 P-value = 0
Less than once a month	< Diff = -48 P-value = 0		> Diff = 2 P-value = 0	> Diff = 2 P-value = 0	> Diff = 7 P-value = 0
Less than once a week but at least once a month	< Diff = -50 P-value = 0	< Diff = -2 P-value = 0		x Diff = 0 P-value = 0.2277	> Diff = 4 P-value = 0
At least once a week but not every day	< Diff = -50 P-value = 0	< Diff = -2 P-value = 0	x Diff = 0 P-value = 0.2277		> Diff = 4 P-value = 0
Every day	< Diff = -54 P-value = 0	< Diff = -7 P-value = 0	< Diff = -4 P-value = 0	< Diff = -4 P-value = 0	

Difference in averages between variables

	Never	Less than once a month	Less than once a week but at least once a month	At least once a week but not every day	Every day
Never		< Diff = -29 P-value = 0	< Diff = -37 P-value = 0	< Diff = -39 P-value = 0	< Diff = -32 P-value = 0
Less than once a month	> Diff = 29 P-value = 0		< Diff = -8 P-value = 0	< Diff = -10 P-value = 0	< Diff = -3 P-value = 0.0004
Less than once a week but at least once a month	> Diff = 37 P-value = 0	> Diff = 8 P-value = 0		< Diff = -2 P-value = 0.01	> Diff = 5 P-value = 0
At least once a week but not every day	> Diff = 39 P-value = 0	> Diff = 10 P-value = 0	> Diff = 2 P-value = 0.01		> Diff = 7 P-value = 0
Every day	> Diff = 32 P-value = 0	> Diff = 3 P-value = 0.0004	< Diff = -5 P-value = 0	< Diff = -7 P-value = 0	

LEGEND:	
<	Significantly lower.
>	Significantly higher.
x	No significant difference.

NOTE: Within country comparisons on any given year are dependent with an alpha level of 0.05.

OECD Average, PIAAC 2012
Organization for Economic Cooperation and Development (OECD)
Program for the International Assessment of Adult Competencies (PIAAC)

Generated using the PIAAC International Data Explorer.

Conclusion

Overall, we found our exploration of the publicly-available PIAAC dataset stimulating and challenging in equal measure. While the scale of the dataset may appear daunting to novice researchers and practitioners, we would encourage readers to undertake their own exploration, using the range of support and tools for analysis available online. Our focus here has been on adults' numeracy practices: just one of the many areas of interest on which data are available in this rich resource. Ultimately, the choice of focus lies with the reader. Our advice is: start with a simple question – something that intrigues you - and take it from there.

[23] See below for an explanation of p-value.

References

AIR PIAAC Team. (nd). What You Need to Consider Before Working with PIAAC Data. Retrieved from http://static1.squarespace.com/static/51bb74b8e4b0139570ddf020/t/54e773d7e4b0328389a39b36/1424454615327/WorkingWithPIAACData_022015.pdf

Black, S., & Yasukawa, K. (2014). Level 3: Another single measure of adult literacy and numeracy. *Australian Educational Researcher, 41*, 125-135. doi:10.1007/s13384-013-0097-9

Bynner, J., & Parsons, S. (1998). *Use it or Lose it? The impact of time out of work on literacy and numeracy skills*. London: Basic Skills Agency.

Bynner, J., & Parsons, S. (2000). The impact of poor numeracy on employment and career progression. In C. Tikly & A. Wolf (Eds.), *The Maths We Need Now: Demands, deficits and remedies* (pp. 26-51). London: Institute of Education, University of London.

Dale, A., Watham, J., & Higgins, V. (2008). Secondary analysis of quantitative data sources. In P. Alasuutari, L. Bickman, & J. Brannen (Eds.), *The Sage Handbook of Social Research Methods* (pp. 520-535). London: Sage Publications.

De Vaus, D. A. (2014). *Surveys in Social Research* (6th edition ed.). London: Routledge.

Frankfort-Nachmias, C., Nachmias, D., & DeWaard, J. (2015). *Research Methods in the Social Sciences* (8th ed.). Basingstoke: Macmillan Education.

Hansen, K., & Vignoles, A. (2007). The Use of Large Scale Data-sets in Educational Research. Retrieved from http://www.tlrp.org/capacity/rm/wt/vignoles

Heaton, J. (1998). Secondary Analysis of Qualitative Data. *Social Research Update 22*. Retrieved from http://www.soc.surrey.ac.uk/sru/SRU22.html

Ministry of Education, & Ministry of Business Innovation and Employment. (2016a). *Skills and Education: Survey of Adult Skills*. Retrieved from Wellington: http://www.educationcounts.govt.nz/publications/series/survey_of_adult_skills

Ministry of Education, & Ministry of Business Innovation and Employment. (2016b). *Skills at Work: Survey of Adult Skills*. Retrieved from Wellington:

Ministry of Education, & Ministry of Business Innovation and Employment. (2016c). *Skills in New Zealand and Around the World: Survey of Adult Skills*. Retrieved from Wellington: http://www.educationcounts.govt.nz/publications/series/survey_of_adult_skills

Montt, G. (2015). *The Causes And Consequences of Field-of-Study Mismatch: An analysis using PIAAC*. Retrieved from Paris: http://www.iza.org/conference_files/worldb2015/montt_g22354.pdf

OECD. (2010). *The OECD Programme for the International Assessment of Adult Competencies (PIAAC)*. Retrieved from Paris: http://www.oecd.org/edu/skills-beyond-school/41690983.pdf

OECD. (2012). *Literacy, Numeracy and Problem Solving in Technology-Rich Environments - Framework for the OECD Survey of Adult Skills*. Retrieved from Paris: http://www.oecd.org/document/0/0,3746,en_2649_201185_49886336_1_1_1_1,00.html

OECD. (2013a). *OECD Skills Outlook 2013: First Results from the Survey of Adult Skills*. Retrieved from Paris: http://dx.doi.org/10.1787/9789264204256-en

OECD. (2013b). *The Survey of Adult Skills. Reader's Companion*. Retrieved from Paris: http://www.oecd.org/site/piaac/publications.htm

OECD. (2013c). *Technical Report of the Survey of Adult Skills (PIAAC)*. Retrieved from Paris: http://www.oecd.org/site/piaac/_Technical Report_17OCT13.pdf

OECD. (2016a). *Skills Matter. Further results from the Survey of Adult Skills*. Retrieved from Paris: http://www.oecd.org/skills/skills-matter-9789264258051-en.htm

OECD. (2016b). *The Survey of Adult Skills Reader's Companion Second Edition*. Retrieved from Paris: http://www.oecd.org/skills/piaac/The_Survey_of_Adult_Skills_Reader's_companion_Second_Edition.pdf

OECD. (nd-a). *PIAAC Reading Components – Sample items*. Retrieved from Paris: http://www.oecd.org/site/piaac/Reading Components Sample Items.pdf

OECD. (nd-b). Problem Solving in Technology-rich Environments. Retrieved from http://www.oecd.org/site/piaac/Problem Solving in TRE Sample Items.pdf

OECD, & Statistics Canada. (2000). *Literacy in the Information Age: Final report of the International Adult Literacy Survey*. Retrieved from Paris and Ottawa: https://www.oecd.org/edu/skills-beyond-school/41529765.pdf

Sabatini, J. P., & Bruce, K. M. (2009). *PIAAC Reading Component: A conceptual framework*. Retrieved from Paris: http://www.oecd-ilibrary.org/content/workingpaper/220367414132

Satherley, P., Lawes, E., & Sok, S. (2008). *The Adult Literacy and Life Skills (ALL) Survey: Overview and international comparisons*. Retrieved from Wellington, NZ: http://www.educationcounts.govt.nz/publications/assessment/19491

Satherley, P., Lawes, E., & Sok, S. (2009). *The Adult Literacy and Life Skills (ALL) Survey: Education, work and literacy*. Retrieved from Wellington, NZ: http://www.educationcounts.govt.nz/publications/literacy/33225/1

Statistics Canada, & OECD. (2005). *Learning a Living: First results of the Adult Literacy and Life Skills Survey*. Retrieved from Paris: http://www.oecd.org/education/innovation-education/34867438.pdf