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U.S. Young Adult Numeracy Skills Lagging Behind: Results from the Newest PIAAC Release 2012/2014

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Abstract: This paper analyzes the numeracy skills of U.S. young adults in comparison with selected peer countries using data from the Program for the International Assessment of Adult Competencies (PIAAC).

Keywords: PIAAC, young adult education, numeracy

Introduction

This paper analyzes the numeracy skills of U.S. young adults (16-34 years old) in comparison with France, Germany, Japan, South Korea, and Sweden using data from the Program for the International Assessment of Adult Competencies (PIAAC).

PIAAC is a large-scale international household study developed by Organization for Economic Co-operation and Development (OECD). PIAAC measures key information-processing skills including literacy, numeracy and digital problem solving, considered essential for successful and full participation in the knowledge-based economies and societies of the 21st century. PIAAC is administered in households to a nationally representative sample of adults 16-65 years old to a minimum sample of 5,000 adults per country. In the first round of PIAAC in 2011-12, around 150,000 adults were surveyed in 23 countries and subnational regions, including the United States. Results from this first round of PIAAC were released in 2013. In the U.S., the study was conducted with a nationally representative sample of 5,000 adults from the target population. In 2013-2014, PIAAC was administered in the U.S. again (aka, the National Supplement study) to 3,600 additional adults aged 16-74. The new round was designed to supplement the first-round sample and to allow the U.S. to know more about three subgroups of interest, by increasing the sample size of unemployed adults age 16-65 and young adults age 16-34, and expanding the sample to include older adults (ages 66-74). In addition to direct assessments of skills, the study collects extensive background information on the participants' educational attainment, formal and non-formal training, past and present employment, civic engagement and political efficacy, well as health status and preventive health.

This paper aims to introduce researchers to the findings of the upcoming PIAAC Young Adults Report (anticipated to be released in winter 2016/2017) through a specific, comparative focus on numeracy skills. In doing so, we will also introduce researchers to a variety of PIAAC research tools (such as the International Data Explorer) that can be used by researchers for further analysis.

Our comparative research is motivated by the anxiety expressed by multiple policymaking stakeholders regarding the future competitiveness of the U.S. economy in numeracy-related fields. Xue and Larson (2015) note high demand in the certain private sector STEM labor

markets, and a 2014 report by labor market analytics firm Burning Glass Technologies predicts that STEM labor market growth will outpace non-STEM labor market growth in future years. Within the global context, a 2015 National Science Foundation report notes that "27% of college graduates working in [Science and Engineering] occupations were foreign-born… in comparison, the share of foreign born among the overall population in the United States was 13% in 2010" (pg. 19). With the millennial generation making up the future of the labor force, it becomes increasingly important to understand their numeracy skills within a comparative context. Additionally, by introducing researchers to a variety of tools for analyzing new PIAAC data, we hope to inspire further research in this field.

Our paper will proceed with the following structure. First, we will describe the framework for the PIAAC numeracy assessment in order to contextualize this paper's understanding of numeracy skills. Additionally, we will detail the assessment design of PIAAC, describing the process by the assessment take places. We will then move on to a series of descriptive statistics from PIAAC. We limit our analysis to numeracy skills, comparing U.S. young adults to their peers in France, Germany, Japan, South Korea, and Sweden in order to give a more focused comparison across analyses. These countries also represent both a range of average scores and of geographic areas with which the U.S. generally compares itself internationally (Western Europe, Nordic countries, and East Asia). Further analysis in this paper will draw upon variables obtained via the background questionnaire of the PIAAC study. Specifically, we will draw upon indicators of each respondent's gender, educational attainment, parental education level, and occupation. After analyzing descriptive statistics across countries, we will utilize regression modeling provided by the PIAAC International Data Explorer to determine the relationship between the background variables and the average numeracy scores for each country. This paper will conclude with a discussion of the implications of our findings and provide resources for further PIAAC research.

Framework and Assessment Design

The PIAAC numeracy assessment was created based on a comprehensive framework developed by a team of international numeracy experts. The framework defines numeracy as follows: "Numeracy *is 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*" (PIAAC Numeracy Expert Group, pg. 22). This definition improves upon the definition of quantitative literacy of the previous national and international studies by highlighting the full range of cognitive processes involved in numeracy and expanding the range of mathematical content assessed beyond basic mathematical skills to include tasks that involve objects or pictures, graphs, and technology-based displays; and that require understanding measurement concepts and procedures, geometric displays, and working with formulas.

Countries, including the U.S., that participated in PIAAC are required to follow a set of standards and guidelines in (a) sampling, (b) data collection including conducting similar training for interviewers, (c) assessment instruments including assessment items and background questionnaire, (d) weighting, and (e) reporting the data, so that results would be comparable across countries, and languages.

The PIAAC assessment design is unique. It is the first large-scale, adaptive assessment conducted on computers. The assessment begins with a Background Questionnaire which focuses on identifying skills not covered by direct assessment including education and training (past and present); work experience; skills used at work and outside of work; literacy, numeracy, and information and communication technology skill use at work and at home; personal traits (such as effort and ambition), and background information including gender, age, and socioeconomic and migration statuses.

After the background questionnaire, respondents are asked to complete the direct assessment on either computer or paper and pencil. Respondents that refuse to take the assessment on the computer will be re-routed to the paper and pencil version of the assessment. The computer-based version is adaptive and items are given to respondents based on their performance on the core literacy and numeracy items. Respondents unable to complete core items are directed to the reading components domain. The assessment is administered to individuals in their homes and takes approximately one and a half hours to complete.

In order to obtain the most complete understanding of a respondent's numeracy skills, PIAAC numeracy items utilize a free-response format and spread over different levels of ability. Respondents are placed on a scale score range of 0-500. To make clearer sense of these numeric scores, PIAAC provides proficiency levels that describe the tasks that respondents are able to perform for any given score. These proficiency levels are provided in table 1 of the appendix.

Descriptive Statistics

The PIAAC results show that U.S. adults overall (age 16 to 65) did not perform well compared to their peers internationally across all the three PIAAC domains. U.S. young adults also performed poorly in all three domains. In literacy, the U.S. young adults were significantly below 10 countries. In numeracy, U.S. young adults only ranked above Spain, and on digital problem solving they did not score higher than young adults in any other OECD country. Although the PIAAC data show there is a strong relationship between educational attainment and skill level across countries, the skills of the U.S. young adults are even lower than their international peers with similar levels of education. When using the 2012 PIAAC data to compare young adults in the U.S. to their international peers by educational attainment, it is clear that even the high levels of education for many U.S. millennials do not necessarily translate to higher skills (Goodman et al., 2015).

Looking specifically at the reference groups for this paper, table 1 shows that the U.S. scored significantly lower than the five other countries chosen. Only the U.S. and French young adults have average scores within level 2 of numeracy, while Germany, Japan, South Korea, and Sweden perform within level 3. Indeed, the U.S. has a higher percentage of young adults performing below level 1 (6) than the five other countries (with the exception of France), and significantly less performing at level 3 (29 versus 35, 39, 47, 47, and 40 for France, Germany, Japan, South Korea, and Sweden, respectively).

This pattern continues even when separating the data by multiple subgroups. Indeed, there is not a single category in which U.S. young adults scored significantly higher than their international

peers. Young U.S. men and women both scored significantly lower than their international peers. Additionally, only U.S. young adults with graduate or professional degrees scored consistently

Table 1: Average numeracy scores by selected characteristics and jurisdiction: 2012/2014

Characteristic	United States		France		Germany		Japan		South Korea		Sweden	
	Avg. Score	Pct.	Avg. Score	Pct.	Avg. Score	Pct.	Avg. Score	Pct.	Avg. Score	Pct.	Avg. Score	Pct.
All Young Adults	261	100	267*	100	279*	100	291*	100	281*	100	283*	100
Gender												
Male	267	51	272*	49	284*	51	295*	52	283*	50	289*	52
Female	255	49	261*	51	273*	49	287*	48	278*	50	261*	48
Education Level												
Below high school	228	20	236*	24*	256*	31*	267*	19	271*	16*	255*	28*
High school credential	254	49	261*	47*	282*	48	287*	41*	277*	46*	286*	49
Associate's degree	277	9	291*	10	288	7*	289*	15*	278	17*	313*	6*
Bachelor's degree	297	16	301	9*	311*	4*	317*	21*	298	20*	315*	9*
Graduate or professional degree	309	6	314	9*	317	10*	‡	3*	‡	1*	310	8*
Parental Education Level												
Neither parent has high school credential	223	11	247*	21*	238	6*	‡	4*	271*	22*	261*	12
At least one parent has high school credential	253	39	267*	47*	273*	47*	284	43*	278*	45*	281*	33*
At least one has college degree	278	50	292*	32*	295*	47	299*	53	291*	33*	293*	54
Occupational classification												
Elementary	241	13	241	11	262*	9*	278*	8*	269*	9*	268*	9*
Semi-skilled blue-collar	256	13	250	23*	264	23*	285*	19*	268*	14	284*	20*

Semi-skilled white-collar	256	38	263*	30*	278*	35*	288*	46*	279*	46*	282*	39
Skilled	285	36	296*	35	300*	33	313*	28*	293*	31*	311*	31*

* Significantly different from U.S.
‡ Reporting standards not met.

on par with young adults from the reference countries. U.S. young adults with high school credentials or below scored significantly less than all other reference countries, and U.S. young adults with Associate's or Bachelor's degrees faired only slightly better, with scores being not significantly different compared to two other countries. Across all levels of parental education, U.S. young adults scored significantly lower than all five other countries, while scoring only equivalent to France in the bottom two categories of occupational classification.

It would be reasonable to think that the overall scores of U.S. young adults lag behind their international peers simply because their peers have more advanced degrees, have parents with more advanced degrees, or work in higher-skilled occupations. However, the percentages given in table 1 provide a much more complex picture. The U.S. has young adults who generally attain bachelor's degrees at similar or even higher rates than their international peers. Additionally, the U.S. ranks below no other country (and ranks above two) with regard to young adults who have at least one parent with a college degree. Finally, the U.S. has the highest percentage of young adults working in skilled occupations.

The general conclusion to be drawn from these descriptive statistics is that while U.S. young adults are demographically similar to their international peers, they are simply not performing at the same level when compared across such demographic groups.

Regression

To further understand the strength of the relationship between certain demographic characteristics and the measured numeracy skills of young adults, we utilize the regression feature given in the International Data Explorer (IDE). The PIAAC IDE regression tool allows users to perform simple linear regressions with PIAAC variables.

For our model, we use the parental education and educational attainment variables given above in table 1. This allows us to analyze two major themes: (a) the varying effects that educational contexts have within each country on young adult numeracy skills and (b) the degree to which participation in formal education (measured through the educational attainment variable) overcomes the educational context within which young adults developed early on (measured through the parental education level). The motivation of (b) comes from a concern over the central tenant of most educational systems, which is to offer students a chance at personal intellectual development regardless of demographic context. Educational systems are often considered "successful" if they are able to help students of a lower SES status to the same degree that they help students of a higher SES status.

Table 2 (below) shows the regression coefficients for the two variables discussed above, by country. The intercept signifies the expected numeracy score for young adults when they have

attained less than a high school credential and whose parents have not attained a high school credential, either. Immediately, it is clear that U.S. young adults in such a situation are far worse off than young adults in other countries. U.S. young adults score well below the level 2 numeracy proficiency threshold, while other countries are either very close or well above the threshold.

Table 2: Regression coefficients and significance, by jurisdiction: 2012/2014

Variable	United States	France	Germany	Japan	Korea	Sweden
Intercept	203.4	222.6	224.7	265.2	258.8	237.5
High parent education (derived)						
At least one has attained HS	24.1*	16.5*	28.3*	-1.3	7.6*	19.3*
At least one has attained college	41.3*	34.8*	46.5*	8.6	21.0*	27.1*
Education						
Upper secondary	22.5*	24.8*	21.2*	19.4*	8.1*	25.8*
Post-secondary, non-tertiary	24.8*	50.4*	42.5*	20.7*	N/A	41.8*
Tertiary – professional	43.5*	55.0*	29.8*	45.7*	11.4*	53.4*
Tertiary - bachelor	58.3*	66.1*	47.3*	60.7*	28.6*	54.1*
Tertiary – master/research	68.5*	53.6*	52.3*	11.8	28.8*	51.1*

* Denotes significance

The second finding that stands out is the relatively high degree of "work" that is done by the parental education variable in the U.S. and Germany. Higher levels of parental educational attainment are on par (in terms of numeracy score increases) with the first few levels of post-secondary education in both countries, meaning that having a parent who attains higher levels of education is just as valuable as many years of formal education for young adults in those countries. This is certainly not the story in Japan and Korea (and, to a lesser degree, France and Sweden), where parental education does very little in terms of numeracy score increase, especially relative to the gains made via formal education by the young adults themselves.
The final finding is that, to a large degree, the gains made by young adults in numeracy skills via formal education is rather similar to the gains made by their international peers. Upper secondary education generally increases numeracy scores by 20-25 points, and a bachelor's degree translates to a score increase of about 55-65. At first, this does seem encouraging at first, but one has to remember that these gains for U.S. young adults are made onto a very low starting point. In order to maintain parity with the rest of the world, the U.S. education system would have to pull almost double its current weight to put students at the same level of those in other countries. For example, among those whose parents have not attained a high school credential, a student with a bachelor's degree in the U.S. would likely be at the same level as a Japanese student who hasn't even achieved a high school degree.

Conclusion

This paper has sought to introduce researchers to PIAAC data via analysis of U.S. young adult numeracy skills within a comparative context. Our analysis reveals that U.S. young adults generally performer lower in numeracy across most demographic factors. This finding holds consistent when analyzed via linear regression, which shows us that the gains made by U.S.

young adults at each level of education, while on mostly on par with the rest of the world, is not enough to make up the gap. Further analysis is needed to determine why the "baseline" score of U.S. young adults is so low, and such analysis is certainly possible with the resources provided by PIAAC data.

Appendix

Table 1: Description of PIAAC numeracy discrete proficiency levels

Proficiency level and score range	Task descriptions
Below Level 1 0 - 175	Tasks at this level require the respondents to carry out simple processes such as counting, sorting, performing basic arithmetic operations with whole numbers or money, or recognizing common spatial representations in concrete, familiar contexts where the mathematical content is explicit with little or no text or distractors.
Level 1 176 - 225	Tasks at this level require the respondent to carry out basic mathematical processes in common, concrete contexts where the mathematical content is explicit with little text and minimal distractors. Tasks usually require one-step or simple processes involving counting, sorting, performing basic arithmetic operations, understanding simple percents such as 50%, and locating and identifying elements of simple or common graphical or spatial representations.
Level 2 226 - 275	Tasks at this level require the respondent to identify and act on mathematical information and ideas embedded in a range of common contexts where the mathematical content is fairly explicit or visual with relatively few distractors. Tasks tend to require the application of two or more steps or processes involving calculation with whole numbers and common decimals, percents and fractions; simple measurement and spatial representation; estimation; and interpretation of relatively simple data and statistics in texts, tables and graphs.
Level 3 276 - 325	Tasks at this level require the respondent to understand mathematical information that may be less explicit, embedded in contexts that are not always familiar and represented in more complex ways. Tasks require several steps and may involve the choice of problem-solving strategies and relevant processes. Tasks tend to require the application of number sense and spatial sense; recognizing and working with mathematical relationships, patterns, and proportions expressed in verbal or numerical form; and interpretation and basic analysis of data and statistics in texts, tables and graphs.
Level 4 326 - 375	Tasks at this level require the respondent to understand a broad range of mathematical information that may be complex, abstract or embedded in unfamiliar contexts. These tasks involve undertaking multiple steps and choosing relevant problem-solving strategies and processes. Tasks tend to require analysis and more complex reasoning about quantities and data; statistics and chance; spatial relationships; and change, proportions and

	formulas. Tasks at this level may also require understanding arguments or communicating well-reasoned explanations for answers or choices.
Level 5 376 - 500	Tasks at this level require the respondent to understand complex representations and abstract and formal mathematical and statistical ideas, possibly embedded in complex texts. Respondents may have to integrate multiple types of mathematical information where considerable translation or interpretation is required; draw inferences; develop or work with mathematical arguments or models; and justify, evaluate and critically reflect upon solutions or choices.