Commissioned Paper
February 2015

Cognitive Skills in the U.S. Labor Market: For Whom Do They Matter?

Authors:
Harry J. Holzer
Robert I. Lerman

Suggested Citation: Holzer H. J. and Lerman R. I. (2015). *Cognitive Skills in the U.S. Labor Market: For Whom Do They Matter?* Retrieved [insert date], from [insert website].

This project has been funded by the American Institutes for Research through a contract with the National Center for Education Statistics (NCES) of the U.S. Department of Education. This report is based on PIAAC data released in October 2013. The views expressed in this paper do not necessarily reflect the views or policies of the American Institutes for Research, National Center for Education Statistics, or the U.S. Department of Education, nor does mention of trade names, commercial products, or organizations imply endorsement of same by the U.S. Government.

AIR-PIAAC Contact:

Jaleh Soroui (AIR-PIAAC Director)
Saida Mamedova (Senior Research Analyst)
PIAACgateway.com
piaac@air.org

Authors Contact:

Georgetown University and American Institutes for Research. Washington, DC.
Harry J. Holzer at hjh4@georgetown.edu
American University and Urban Institute. Washington, DC.
Robert I. Lerman at blerman@urban.org

COGNITIVE SKILLS IN THE U.S. LABOR MARKET:

For Whom Do They Matter?

Harry J. Holzer

Georgetown University and AIR

Robert I. Lerman

American University and Urban Institute

We thank Aaron Gregg and Jieling Xu for their computational assistance, as well as Jaleh Soroui, Emily Pawlowski, Saida Mamedova and an anonymous reviewer for helpful comments.

Introduction

Skills are central to productivity growth and earnings. Studies find variations in human capital account for a large share of variations in economic growth (Mankiw, Romer, and Weil 1992). But, what is skill? How should we measure the levels of human capital in an individual and in a country? Until recently, the primary measures of skill were years of schooling and work experience. In fact, tests of human capital theory relied exclusively on these two measures. Hundreds of studies have estimated the benchmark earnings equation linking percentage differences in earnings to years of schooling, years of work experience, and the square of years of work experience.

Although these equations have a reasonably good record of predicting earnings, economists have long realized that schooling and work experience are proxies for the skills that actually contribute to productivity, including cognitive skill, general employability skills, and occupational skill. Recently, with the availability of data on tests of skills in math, science, and reading comprehension for the work force as a whole, new studies are reexamining the link between skills, earnings, and economic growth. In their analyses of differences in economic growth across countries, Hanushek and Wößmann (2008, 2012) find that cognitive skills are far more important than the amount of schooling. Others find that the non-cognitive gains from educational attainment appear to be important too, above and beyond the individual's cognitive skills. For example, workers with a high school diploma and with a GED involving fewer years of schooling have similar test scores on cognitive skills. Yet, those with a high school diploma do far better in the work force (Lerman 2008, p. 35).

In the U.S. context, both researchers and policymakers still rely mostly on educational attainment as the measure of skill of the work force. In a widely cited book, Katz and Goldin (2008) focus on the slowdown in the growth of schooling and argue that speeding up economic growth and reducing wage inequality require a more rapid growth in educational attainment. Central to President Barack Obama's education agenda is the goal that by 2020 the U.S. again becomes the international leader in the share of the population completing a BA degree. At the same time, the last two Administrations have emphasized student testing of cognitive skills, thus highlighting the direct role these skills play in the economy and worker earnings.

This paper draws on a rich, new source of data to reexamine the respective roles of cognitive skills, problem-solving skills, years of schooling and other factors in determining earnings within the U.S. We ask several questions, including:

- How do the results of tests of cognitive skills vary across and within educational levels?
- Do cognitive skills affect earnings, over and above the effects of educational attainment?
- Does educational attainment still influence earnings, after taking account of cognitive skills?
- Which cognitive skills—math, reading, or problem-solving—matter most?

- Does the influence of cognitive skills come entirely from helping people get into high pay occupations or do differences in cognitive skills affect earnings differences within fields?
- Does the role of cognitive skills in affecting earnings differ for men and women?

The next section describes the data and the analytic methods. Section 3 begins with tables showing how cognitive skills vary by educational group and other characteristics. Next, we present estimates of the relationship between cognitive skills, educational attainment, and other factors on earnings. The results document the critical importance of cognitive skills, above and beyond the effects of schooling. We conclude with a discussion of how these results should influence researchers and policymakers to look at human capital in a comprehensive way.

Description of Data and Analysis

The Program for the International Assessment of Adult Competencies (PIAAC) is the most comprehensive initiative to collect cognitive skills data across countries. Administered to 160,000 individuals ages 16 thru 65 in 24 (mostly) OECD countries during the period August 2011-March 2012[1], the PIAAC survey and testing initiative has compiled information on adult skills in three categories: literacy, numeracy, and problem-solving in technology-rich environments (OECD 2013a, 2013b). The individual tests were originally graded on scales of 0-500 and then transformed into corresponding levels of 0-5 for literacy and numeracy (or 0-3 for problem solving in technology-rich environments); we use these same categories in our analysis. The accompanying survey asked a variety of questions on skills, such as the extent to which respondents use these skills on their current or most recent jobs. These estimates yield relevant information on labor market demand for skills used on jobs as well as their supply among workers.[2]

In addition to testing for skills, the survey collected data on each respondent's demographic characteristics (such as age, gender, foreign-born status), educational attainment or other training completed, and labor market experience, including the respondent's recent work history, occupation, and usual monthly earnings. Earnings is the primary outcome variable of our analyses; it is a measure of gross earnings (in other words, before taxes and other deductions) and includes regular overtime, bonuses, tips and commissions but not benefits or holiday pay.[3]

We limit our analysis to the roughly 5,000 observations generated for the U.S. Of these, we focus on those aged 25-65, to avoid students who mostly work part-time and have not completed their educational attainment. When analyzing the effects of cognitive skills on

---

[1] The survey was administered in the 22 OECD countries plus Russia and Cyprus.

[2] We do not use these perceived demand-side measures of U.S. workers in our analysis here, because of their subjectivity and likely measurement errors.

[3] In the publicly available (unrestricted) PIAAC data files, the monthly earnings measure reported for each individual is only the docile in the earnings distribution in which the individual appears. We used the restricted file available to researchers at the American Institutes for Research for our earnings analysis here, though these results are quite consistent with what we found in our preliminary analysis of the unrestricted public data file.

earnings, we limit our sample to those with earnings of no less than $500 per month but no more than $20,000. The maximum limit is meant to prevent outliers from dominating the estimates. The lower limit allows us to avoid having to distinguish among those with zero earnings, some of whom choose voluntarily to leave the labor force and others who have zero earnings because they cannot find or keep a job. We examine skill patterns and earnings for all workers and for key subgroups, by age (25-34 year olds vs. 35-65 year-olds), by sex and by foreign-born status.

We classify the measured skill levels in each skill category into "highly proficient" (levels 4-5), "proficient" (level 3), or "low proficiency" (levels 2 and below).[4] [5] To analyze the extent to which these proficiency levels correlate with our usual measures of human capital attainment, we use the 5-category measure of educational attainment (high school dropout, high school graduate, some college, bachelor's degree and schooling above that level). We also use a distribution of occupational categories that corresponds quite closely to the standard 1-digit scheme used by the Bureau of Labor Statistics in the U.S.

After examining summary statistics on skill levels, we present regression estimates of the relationship between proficiency levels and monthly earnings. The estimates provide measures of association both with and without controlling for factors other than skill measures. The equation with the most controls takes the following form:

$$\text{EARN}_{\text{i}} = \text{f}(\text{PROF}_{i\text{z}}, \text{HIPROF}_{iz}; \text{DEMOG}_{i}; \text{ED}_{i}; \text{OCC}_{i}) + \text{u}_{i}\,,$$

where EARN represents monthly earnings, either in natural log or linear form;[6] PROF_z and HIPROF_z are dummy variables for proficiency and high proficiency respectively (relative to low proficiency) for test Z, which represents literacy, numeracy or problem-solving in a technology-rich environment (with all of these variables included simultaneously in our initial regressions); DEMOG represents dummy variables for age, gender and foreign-born status; ED represents dummies for educational attainment; and OCC represents 1-digit occupation dummies, all for individual *i*.

We present three versions of equation (1) each for linear and log earnings. The first omits education and occupation control variables, the second includes education variables only, and the third includes both education and occupation. Since basic literacy and numeracy skills are likely important causal determinants of educational attainment and occupation, the estimates without controls for education and occupation are important for gauging the overall effects of cognitive

[4] For problem-solving, reported in levels 0-3, level 3 was used to designate "high proficiency", level 2 represented "proficiency", and level 1 or below represented "low proficiency".

[5] In the OECD analyses, levels 2 and 3 are both considered proficient but 1 and below are not. In our analysis, we interpret scores of 2 or less to indicate "low proficiency" rather than no proficiency.

[6] Economists tend to prefer the natural log (ln) specification for earnings, since changes in this measure approximate percent changes in earnings. Since a given absolute change in earnings likely matters less to individuals at the top of the earnings distribution than at the middle or bottom, percent changes more likely capture the relevant change accurately.

skills on earnings. The sequence of estimates enables us to see the extent to which cognitive skills affect earnings indirectly, through educational attainment or occupation, or exert direct effects that are present after controlling for education and occupation. The third set of regressions measures the effects on earnings of literacy, numeracy, and problem-solving skills *within* education and/or occupation as well as between them. The results show whether cognitive skills affects earnings, even in occupations not requiring high levels of education. [7] All regressions are estimated by Ordinary Least Squares (OLS) and use demographic variables (age, gender and foreign-born status) as controls.

Two other statistical issues deserve mention here. First, we use sample weights to generate population-wide summary statistics below. But, following Winship and Radbill (1994) and many other economists and sociologists, we do not use sample weights when estimating any regressions, since unweighted estimates are considered more unbiased and efficient. Second, we use only the most plausible point estimates of skill measures provided in the PIAAC data in all of our analysis, rather than the fuller range of plausible estimates generated there, since other work on test score data has shown very little effect from using the former instead of the latter.[8]

Results

Summary Statistics

The overall results in Table 1 illustrate that proficiency rates of Americans in literacy and numeracy skills are quite low. The results are consistent with other analyses of the PIAAC data indicating U.S. proficiency is low relative to other countries.[9] Using our slightly more stringent measures of proficiency (compared to the OECD), only about half of American adults are at least proficient in literacy and only 40 percent in numeracy and problem solving. Correspondingly, the shares of U.S. adults scoring in the highly proficient categories are quite low; only about 16 percent of Americans are highly proficient in literacy, only 13 percent in numeracy, and 7 percent in problem-solving.

These relatively low rates of proficiency are observed widely across most demographic sub-groups. We see comparable or slightly higher proficiency among men than women and among younger Americans than older ones. The proficiency levels are significantly higher among the native-born. Yet the lack of proficiency even among the young and native-born is quite striking.

[7] Cross-tabulations between literacy, numeracy and problem-solving proficiency measures of individuals are available from the authors.

[8] According to Hanushek and Wossman (in their 2012 paper), using the full range of plausible PIAAC scores did very little to change the findings in their work, so they also use only the most plausible values. More generally, using only the most plausible value might lower estimate efficiency a bit but should not generate bias. In the analysis of Carstens and Hastedt (2010), using only the most plausible value generated estimates (with the TIMSS 2007 data) that deviated very little from those obtained using the full plausible range; in their work, only the use of other Bayesian methods generated substantial deviations in estimated values from the full range.

[9] See OECD (2013a b).

One surprising result is the similar rates of proficiency of 25-34 year-old men and women. These results contrast with other U.S. data (such as the National Educational Longitudinal Survey, or NELS) showing proficiency in literary skills and educational attainment are considerable higher for young women than for men (Holzer and Dunlop, 2013). The lack of a "gender gap" in these data suggests that low-income men might be undercounted in the U.S. PIAAC data, as they are in many other American surveys (e.g., U.S. Census Bureau 2012). If true, the already low rates of proficiency for literacy and numeracy observed here among Americans are likely to be upward biased.

How do these measures of skill proficiency correlate with other measures of skill development, such as educational attainment and occupation? Tabulations of proficiency by education and occupation appear in Tables 2 and 3 respectively. Cross-tabulations of education and occupation by demographic group are also presented in the Appendix tables, to give us a clearer sense of how our population subgroups are distributed across these other measures of skill.

Table 2 demonstrates that, as expected, literacy and numeracy skills are highly correlated with educational attainment, though the correlation appears a bit weaker for problem-solving skills. Still, within each category, skill proficiency varies a good deal. Moreover, the PIAAC tests show low proficiency is not uncommon among workers at middle and high levels of education.

Proficiency is very low among US high school dropouts; less than 20 percent are proficient in literacy and less than 10 percent are proficient in numeracy. Virtually no dropouts achieve high levels of proficiency. These patterns are the same among young dropouts as well as older ones.[10]

What is especially disturbing is that the low proficiency levels in literacy and numeracy extend to workers with only high school diplomas (but no college). Low proficiency is the norm for high school graduates, with about 60% and 75% showing low proficiency in literacy and numeracy respectively, while about 70% do so in problem-solving. Again, high proficiency is quite rare.

Even among those with Bachelor's degrees (BAs), a significant minority—over one in four—test below literacy proficiency, and even higher rates do so in numeracy and problem-solving. Amazingly, even among those with more than a BA, about one in four exhibits low proficiency in numeracy and 18 percent in literacy. Of course, it is likely true that those majoring in the humanities are the ones most likely to have low numeracy proficiency while those in the science or math fields have lower literacy skills, though some lack both.[11] However, given that

[10] Results for education group interacted with age group are available from the authors.
[11] Our cross-tabulations show that nearly over 10% of those with BAs or higher lack proficiency in both areas.

basic literacy is a foundational skill which is likely needed in virtually all occupations to some extent, the low levels of literacy proficiency we observe are surprising and troubling.

The overlap in scores between educational groups is substantial and striking. About 50 percent of those with only some college rank higher in literacy than the 26 percent of BAs who are not proficient, and those proficient among workers with some college rank as high as another 49 percent with BAs. Nearly 40 percent of those with only a high school diploma are in the same proficiency categories as the bottom 75 percent of those holding a BA degree.

By occupation, the rates of skill proficiency observed in Table 3 are broadly correlated with occupational status, but again we find high variation and some substantial fractions of workers with low proficiency in each occupational category. Those in the professional occupations have the highest levels of proficiency, and those in management are also relatively high. The professionals are, of course, the categories where those with education above the BA degree are most often found. But, in occupations that are often considered "middle-skill" (Holzer and Lerman, 2007; Autor, 2010), such as technician and clerical ones, workers exhibit low literacy and numeracy proficiency (40 and 47 percent for literacy and 56 and 63 percent for numeracy, respectively). In other occupations from the middle of the skills or earnings spectrum, such as sales and the crafts, workers have low basic literacy or numeracy skills even more frequently. And among laborers and service workers, low proficiency is the norm, almost to the same extent as we see it in the small group of American agricultural workers. Problem-solving skills are also quite rare in these lower paying occupational strata, as low proficiency in this category is observed quite frequently as well.

With so many Americans showing low skill proficiency, even in middle- or higher-skill educational and occupational categories, what does this imply for the earnings of American workers? Summary results on monthly earnings, overall and by skill proficiency levels, appear in Table 4.[12] For our overall sample of workers, monthly earnings average about $4,300 (over $51,000 on an annual basis).[13] Not surprisingly, average earnings rise with proficiency, increasing 44 and 54 percent respectively when comparing those with low and proficient levels, and 34 percent when comparing proficient and high levels, in literacy and numeracy. Reaching proficiency in problem-solving is associated with a 39 percent increase in earnings compared to having low proficiency; and going from proficient to highly proficient is associated with a 25 percent rise in earnings.

[12] Standard deviations are estimated using a jackknife weighting methodology, which calculates an estimator's variance by resampling from the original sample when a strata only contains one primary sampling unit. More information on how this method was used is available from the authors.

[13] Our unreported tabulations show monthly median earnings in our sample of about $4000. These imply that year-round workers would earn a bit over the median earnings of about $44,000 reported by the Census Bureau (2013), which is not limited to those aged 25-65.

Since proficiency levels are highly correlated with educational attainment and place of birth, it is unclear from Table 4 whether proficiency, educational attainment, native-born status, and/or other factors are causing higher earnings. To distinguish between proficiency, educational attainment and other effects on earnings, we turn to multivariate regressions.

Earnings Regressions for the Total Sample

The regression analyses reported in Table 5 show the independent effects of proficiency levels on the level and natural log of earnings. All equations include a set of demographic variables, there by controlling for age, gender and foreign-born status. In each case in Table 5, the regressions in set 1 use only proficiency levels as explanatory variables. The second and third equations control for education and then occupation (as well as education) respectively.

The results show the close connection between skill proficiency and earnings. On average, without controlling for other measures of skill, literacy proficiency adds about $250 to one's monthly earnings, and high proficiency (relative to low proficiency) adds over $700. Numerical proficiency is linked with much larger associations in each case, with proficiency adding nearly $1000 and high proficiency adding nearly $2000. Given the monthly mean earnings levels observed in Table 4 (just over $4000), these are very large differentials that are also highly significant statistically. Problem-solving proficiency adds about $500 and high proficiency adds over $700 to that amount. Generally, the significance levels and overall fit between the linear and logarithmic equations are very similar. And, given the high correlations in proficiency measures between the three skill categories, the significance of coefficients on individual proficiency measures is notable.

When we control for educational attainment in the next set of equations and then for both education and occupation in the third, the rises in earnings observed with each increase in proficiency level declines substantially. The controls for education generally reduce the magnitudes of estimated numeracy and problem-solving proficiency coefficients by half to two-thirds and eliminate the estimated effects of literacy proficiency; the addition of occupation reduces them further. Still, numeracy and problem-solving proficiencies within educational categories remain significant, as does numeracy proficiency within both education and occupation categories. In fact, controlling for education, high numeracy proficiency adds roughly as much to earnings as does moving from a high school graduate only to a BA degree.

Our estimated equations including only demographic characteristics and our skill proficiency measures account for about 20 percent (R^2 = .19) of the total observed variation in earnings. The inclusion of educational attainment and occupation along with the cognitive skill measures enables the regression to account for nearly 35 percent of total variation (R^2 = .33). Thus, despite the limitations of these measures that lack controls for field of study, industry, and individual performance, the two indicators of skill can account for substantial amounts of earnings variation in the U.S.

Proficiency Impacts by Sex, Age, and Nativity

How do the patterns observed in Table 5 vary across demographic groups? Men may be relatively more rewarded for cognitive skills, given their lower educational attainment levels than women. Cognitive skills may be especially important for younger workers since they are likely hired in increasingly technically demanding jobs and are less able to take advantage of industry experience and seniority. Foreign-born workers could be more likely than native born to require literacy and numeracy to offset potentially negative effects of language on their earnings.

Table 6 presents regression results separately for males and females, younger and older Americans, and native and foreign-born workers. Given the small sample sizes used and the high correlations across skill proficiency categories, we have dropped problem-solving skill proficiency; problem-solving is a newly measured category of skill that has not been widely tested and is not as foundational for further education and training (in our view) as are the other categories. To keep the numbers of regressions manageable, we present results using only absolute earnings and not the log of earnings. F-statistics for literacy, numeracy and both sets of skills appear as well.

The results in Column 1 show significant effects of literacy and numeracy proficiency, and especially high proficiency, for virtually all groups. In most sub-groups, the gain in earnings from increased numeracy exceeds the gain from increased literacy. Men benefit substantially more from increased proficiency in numeracy than women, while the opposite is true for literacy. These gender differences are smaller among the youngest workers (not presented here).[14] The fact that gains from literacy and numeracy fall substantially when educational attainment is taken into account implies that formal education raises both literacy and numeracy. Still, moving from low to proficient in numeracy raises men's earnings by over $900 per month, even after controlling for educational attainment. The gain for women is lower, but still a substantial $469 per month. Given one's educational level, the gain from added literacy is not significant for men and only significant for women at the high proficiency level.

The effects of moving from low to proficient vary by age and type of proficiency. Returns to literacy are higher for 25-34 year-olds than for those 35 and over, while the gains from numeracy are substantially higher for those 35 and over. Once education is taken into account, for the younger group, reaching proficiency in math has no effect on earnings but proficiency in literacy raises earnings by nearly $450 per month. On the other hand, for the older group, moving up from low to proficient status in math is associated with a nearly $900 rise in

[14] In unreported tabulations where we cross-tabulated age and gender, we found numeracy effects that are quite strong for young women as well. This likely indicates the greater entry of younger females into science or technology (STEM) fields where such skills are more highly valued.

monthly earnings while the effect of moving to proficiency in literacy is not statistically significant. In all cases, reaching high levels of proficiency in literacy and numeracy could raise earnings significantly for both age groups, again controlling for educational attainment. These patterns persist at a weaker level even after controlling for occupational status.

Cognitive skills play very different roles for native and foreign-born workers. Without controls on education—thus illustrating the gross effect of numeracy and literacy—the earnings increases associated with moving to proficient status are higher for foreign-born than for U.S.-born workers. However, after taking educational levels into account, proficiency effects on earnings are no longer statistically significant for the foreign-born. But for U.S.-born workers, the returns to numeracy proficiency and especially to high numeracy proficiency are enormous, reaching $1,000-$2,240 per month. Even after including occupational as well as educational controls, the gains from numeracy proficiency for U.S. born remain very large and statistically significant. A U.S. born worker with proficiency in numeracy can expect to have earnings about $9,000 per year higher than a worker with the same education and occupational status. The importance of numeracy skills for earnings has been demonstrated in earlier work (Rose and Betts, 2001), but it is striking to see no gain for the foreign born.

Proficiency Effects by Education and Occupation Groups

To see how the earnings gains associated with cognitive skills vary by education level and by occupational level, we present results in Tables 7 and 8 for each education and occupational category. The educational groups are: high school or less, some college, and BA and above. The occupational groups are: professional/managerial, technical, clerical/sales, craft/operative, and laborer/service occupations. There are two specifications for each equation; one is without occupational controls in education regressions or without education controls in occupational regressions, while the other includes those controls.

The estimates by educational group demonstrate an interesting pattern: the returns to skills demonstrate a U-shaped effect, with the highest impacts found for the least- and most-educated groups. For those with a high school diploma or less, both literacy and numeracy proficiency exert large, significant impacts. For this group, moving from low to proficient status is associated with an additional $529 per month for literacy and almost $790 per month for numeracy. After occupational controls are introduced, the earnings increases associated with numeracy remain but the literacy estimates are no longer statistically significant. Less-educated workers must have well-developed cognitive skills to obtain high earnings in America, both as a precondition for entry into well-paying jobs and in doing well at those jobs.[15]

For those with a BA or higher, numeracy proficiency especially is very highly rewarded; reaching proficiency adds nearly $800 per month and reaching high proficiency adds over $1,900

[15] Heckman (2008) argues that "skill begets skill," implying that strong basic cognitive skills are necessary before higher levels of education or occupational training can be successfully provided to workers.

per month. Apparently, higher education itself is often not sufficient, to guarantee high earnings; with high variance in earnings to those with BAs and above, those with strong numeracy skills are in areas that are relatively better-compensated than those with only strong literacy abilities.[16] On the other hand, variations in literacy proficiency within this BA population do not lead to statistically significant differences in earnings.

The relative returns across occupations in Table 8 also generate some interesting findings. In professional and managerial jobs, numeracy (and especially high numeracy) skills are particularly well-rewarded – consistent with the findings for those with BAs and above in Table 7. Even after controlling for educational attainment, moving from low to high proficiency in numeracy is associated with a jump of over $1,900 per month or over a $23,000 increase on an annualized basis. For technicians, higher literacy levels are more highly rewarded than higher numeracy levels, perhaps by enabling workers with communication skills to enter the higher-skilled ranks of technician jobs. The case of clerical and sales occupations is unusual in not yielding gains from increased levels of literacy or numeracy. This result is surprising. However, craft and operative jobs clearly yield significantly higher earnings for those who are proficient in numeracy. As manufacturing firms increasingly use more sophisticated equipment, craft workers and machine operators can raise their earnings by at least reaching proficiency in numeracy. Surprisingly, reaching the highest levels of numeracy actually display lower earnings than otherwise similar workers at the proficient level. Workers in these occupations gain little or nothing from literacy proficiency, perhaps suggesting that these occupations rarely require writing or sophisticated reading skills. For laborer and service workers, some literacy proficiency seems to enable workers to escape the very bottom rungs of the occupational ladder in America, but proficiency in numeracy yields very little.

Conclusion

The measured levels of skill proficiency in the U.S. are low relative to those in many other OECD countries. Low proficiency in literacy, numeracy and problem-solving can be found in all demographic groups – young and old, male and female, native-born as well as immigrant, and even at higher rungs on the educational and occupational ladders. This analysis of PIAAC data on skill proficiency focuses on how these skills are rewarded in the U.S. labor market. How much do weak cognitive skills matter for earnings? How closely are cognitive skills associated with earnings? Does educational attainment account for all or nearly all the earnings gains associated with these skills? Or, are the gains from skill proficiency sustained, even after accounting for educational attainment? What are the implications for using educational attainment as the proxy for skill, when other skill-related factors affect earnings?

Several findings emerge from the analysis. First, the market generates quite strong rewards to literacy, problem-solving and especially numeracy proficiency. These returns can be

---

[16] For evidence of the high levels of variation in earnings across different groups of college graduates see Carnevale et al. (2011).

found for all demographic groups, for those with low as well as high educational attainment, and in virtually every occupational group. Indeed, literacy and/or numeracy proficiency seem to be preconditions to other forms of more specific occupational training that are needed to advance within all parts of the job market. Second, the gains associated with reading and math proficiency vary widely across groups of workers. Older workers see the highest returns to numeracy while younger workers gain more from literacy. U.S.-born workers benefit a great deal from enhanced numeracy, even after controlling for education. Foreign-born workers see no benefit, once we take account of educational level.

Third, the effect of educational attainment on earnings leaves a great deal of earnings variation linked to proficient and high levels of numeracy and literacy. The patterns differ by educational level. Workers with "some college" see no significant earnings increases with higher levels of cognitive skills. But those with no more than a high school diploma experience markedly higher earnings when they are proficient in literacy and numeracy. A high school graduate who moves from low to proficient in both literacy and numeracy would be expected to obtain a job that pays almost $16,000 more per year. Numeracy skills are especially important for those with BA degrees. Over one in three (37 percent) of BAs are at the lowest proficiency in numeracy. The regression results suggest that raising these workers to proficient in numeracy would raise their earnings by $800 per month in added earnings.

Fourth, cognitive skills raise earnings among those with the same occupation, but not in all cases. For managers and professionals and for craft workers and machine operators, the gain comes from reaching proficient levels of numeracy. For technical and associate professions, added proficiency in literacy is valuable. But, for clerical, sales, laborers, and service workers, higher cognitive skills exert little impact on earnings. Of course, these estimates do not take account of the role of cognitive skills in finding a job in one of these occupations.

Overall, the skill measures compiled for PIAAC are indeed consequential and demonstrate that educational attainment offers only a partial indicator of skills relevant to the labor market. Given the woefully low levels of literacy and numeracy among U.S. workers, the evidence in this paper suggests that insuring more workers attain at least a proficiency skill level would go a long way in raising earnings and productivity.

References

Autor, David. 2010. *The Polarization of Job Opportunities in the U.S. Labor Market*. Washington DC.

Carnevale, Anthony et al. 2011. *What's it Worth? The Economic Value of College Majors*. Center on Education and the Workforce, Georgetown University, Washington DC.

Carstens, Ralph and Dirk Hastedt. 2010. "The Effect of Not Using Plausible Values When They Should Be: An Illustration Using TIMSS 2007 Grade 8 Mathematics Data." Unpublished manuscript, IEA Data Processing and Research Center.

Goldin, Claudia and Lawrence Katz. 2008. *The Race Between Education and Technology*. Cambridge, Massachusetts: Harvard University Press.

Hanushek, Eric and Ludger Wößmann. 2012. "Do Better Schools Lead to More Growth: Cognitive Skills, Economic Outcomes, and Causation." *The Journal of Economic Growth*. 17:4, 267-321.

Hanushek, Eric and Ludger Wößmann. 2008. "The Role of Cognitive Skills in Economic Development." *Journal of Economic Literature*. 46 (3): 607-668.

Heckman, James. 2008. "Schools, Skills and Synapses." IZA Discussion Paper.

Hill, Carolyn et al. 2009. *Against the Tide: Household Structure, Opportunities and Outcomes among White and Minority Youth*. W.E. Upjohn Institute for Employment Research, Kalamazo MI.

Holzer, Harry and Robert Lerman. 2007. *America's Forgotten Middle-Skill Workers: Education and Training Requirements in the Next Decade and Beyond*. The Workforce Alliance, Washington DC.

Lerman, Robert I. 2008. "Are skills the problem? Reforming the Education and Training System in the United States" in *A Future of Good Jobs*. Kalamazoo, Michigan. Upjohn Institute. 17-80.

Mankiw, N. Gregory, David Romer, and David Weil. 1992. "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*. 107(2): 407-437.

OECD. 2013a. *OECD Skills Outlook 2013: First Results from the Survey of Adult Skills*. OECD Publishing.

OECD. 2013b. *Time for the U.S. to Reskill? What the Survey of Adult Skills Says*. OECD Publishing.

Rose, Heather and Julian Betts. 2001. *Math Matters: The Links between High School Curriculum, College Graduation and Earnings*. Public Policy Institute of California, San Francisco.

U.S. Census Bureau. 2012. http://www.census.gov/newsroom/releases/archives/2010_census/cb12-95.html.

U.S. Census Bureau 2013. *Income, Poverty and Health Insurance Coverage in the United States: 2012*. U.S. Department of Commerce.

Winship, Christopher and Larry Radbill. 1994. "Sampling Weights and Regression Analysis." *Sociological Methods and Research*, Vol. 23, No. 2, 230-57.

Table 1: Literacy, Numeracy, and Problem-Solving Levels of U.S. Workers, By Sex, Age, and Nativity									
	Literacy			**Numeracy**			**Problem-Solving**		
	Low	**Proficient**	**High**	**Low**	**Proficient**	**High**	**Low**	**Proficient**	**High**
All workers	50.3	33.8	15.9	60.2	26.5	13.3	59.6	33.3	7.1
Males	49.6	32.8	17.7	54	28.2	17.7	57.7	33.9	8.5
Females	51.0	34.7	14.3	65.8	24.9	9.3	61.6	32.7	5.7
Ages 25-35	46.9	35.3	17.8	56.6	28.6	14.8	53.6	38	8.4
Ages 35+	51.4	33.3	15.3	61.3	25.8	12.9	61.4	31.9	6.7
Foreign-Born	72.8	21.6	5.6	74.5	19.1	6.4	74.3	23.8	1.9
US-Born	48.4	37.8	13.9	60.3	29.2	10.5	57.7	34.5	7.8

Note: All tabulations are population-weighted. Entries in each row within each category sum to 100. Samples here and below are limited to workers age 25-65.

Source: Tabulations by authors from PIAAC public use file.

Table 2: Literacy, Numeracy, and Problem-Solving Levels by Educational Attainment									
	Literacy			**Numeracy**			**Problem-Solving**		
Education Level	**Low**	**Proficient**	**High**	**Low**	**Proficient**	**High**	**Low**	**Proficient**	**High**
High School Dropout	81.1	17.5	1.4	91.1	8.3	0.7	78.7	18.6	2.7
High School Graduates	61.8	32.4	5.8	74.6	21.3	4.2	70.6	25.4	4.1
Some College	50.2	38.3	11.5	63.3	29.8	6.8	63.3	31.4	5.3
4-year Degree	26.3	49	24.7	36.6	44.4	19	42.2	44.2	13.6
Above BA	18.0	47.9	34.1	24.1	47.1	28.8	38.5	51.0	10.5

Note: All tabulations are population-weighted. Entries in each row within each category sum to one.

Source: Tabulations by authors from PIAAC public use file.

Table 3: Literacy, Numeracy, and Problem-Solving Levels by Occupation

	Literacy			Numeracy			Problem-Solving		
Occupation	**Low**	**Proficient**	**High**	**Low**	**Proficient**	**High**	**Low**	**Proficient**	**High**
Senior officials and managers	28.6	45.8	25.6	35.2	40.5	24.3	41.2	46.7	12.1
Professionals	24.6	47.1	28.3	31.7	45.2	23.1	40.8	44.8	14.4
Technicians	40.2	46.6	13.2	56.3	35.3	8.4	59.4	35.4	5.2
Clerks	46.7	41.5	11.7	63.2	27.4	9.4	62.3	32.8	4.9
Service workers	67.7	27.9	4.4	78.2	17.8	3.9	75.2	21.8	3
Skilled agricultural/ fishery workers	83.2	10.4	6.4	84.6	12.7	2.6	84.7	15.3	0
Craft and related trade workers	65.5	27.7	6.9	68.2	26.6	5.2	71.6	24.6	3.8
Plant and machine operators	71.8	25.4	2.8	81.6	16.1	2.3	82.5	14.8	2.8
Laborers	65.2	33.2	1.5	77.3	22.3	0.4	71.8	24.3	3.9
Sales workers	57.4	35.1	7.5	70.2	23.3	6.5	63.1	33.9	2.9

Note: All tabulations are population-weighted. Entries in each row within each category sum to one.

Source: Tabulations by authors from PIAAC public use file.

Table 4: Earnings Means and Standard Deviations

Sample	Earnings Mean	SD
Total	$4,298	74.34
Literacy - Low	3,287	57.13
Literacy - Proficient	4,720	92.21
Literacy - High	6,325	269.83
Numeracy - Low	3,308	54.73
Numeracy - Proficient	5,110	146.44
Numeracy - High	6,824	304.36
Problem-Solving - Low	3,776	68.90
Problem-Solving - Proficient	5,262	114.46
Problem-Solving - High	6,575	157.16

FOOTNOTE: Standard deviations are estimated using jackknife weighting methodology, which calculates an estimator's variance by resampling from the original sample. When a strata only contains one primary sampling unit, there is insufficient information to estimate variance for that strata. The means estimated in table 4 solve this problem by treating single-PSU strata as certainty units which do not contribute to overall variance, exerting downward bias on the estimated standard deviation. This was only necessary when estimating standard deviations for high literacy, proficient and high numeracy, and proficient and high problem-solving.

Table 5: Relationship Between Literacy, Numeracy, and Problem-Solving and Earnings						
		Earnings			LnEarnings	
Literacy	1	2	3	1	2	3
Proficient	248.35	-32.70	-104.43	.105	.040	.019
	(1.47)	(-0.2)	(-0.67)	(2.82)	(1.11)	(0.57)
High	735	260.02	182.01	.167	.062	.038
	(2.8)	(1.01)	(0.75)	(2.87)	(1.10)	(0.73)
Numeracy						
Proficient	955.25	541.96	458.35	.191	.097	.074
	(5.51)	(3.20)	(2.85)	(5.01)	(2.61)	(2.13)
High	1960.73	1274.06	1183.25	.331	.179	.166
	(7.20)	(4.76)	(4.66)	(5.53)	(3.06)	(3.02)
Problem-Solving						
Proficient	482.81	362.24	113.17	.128	.010	.040
	(2.89)	(2.25)	(0.73)	(3.48)	(2.80)	(.68)
High	728.51	673.41	303.29	.181	.161	.072
	(2.46)	(2.36)	(1.12)	(2.77)	(2.57)	(-.98)
Education Controls	No	Yes	Yes	No	Yes	Yes
Occupation Controls	No	No	Yes	No	No	Yes
Adjusted R-Squared	.19	.25	.33	.18	.25	.34

NOTE: Statistical significance defined at P<.10. All regressions include gender, age and foreign-born controls. T-values appear in parentheses below coefficients.

Table 6: Literacy, Numeracy Levels and Earnings Relationships, by Sex, Age, and Place of Birth

By Gender		Males			Females		
		1	2	3	1	2	3
Literacy	Proficient	606.79	230.26	79.32	586.48	222.41	82.92
		(2.42)	(0.94)	(0.34)	(3.21)	(1.27)	(0.50)
	High	991.39	348.21	251.43	1373.44	859.43	547.54
		(2.61)	(0.94)	(0.71)	(4.69)	(3.06)	(2.06)
Numeracy	Proficient	1421.95	902.39	663.78	1024.86	469.26	291.58
		(5.60)	(3.61)	(2.77)	(5.29)	(2.48)	(1.63)
	High	2795.65	1845.61	1393.56	1773.49	1066.08	974.22
		(7.43)	(4.96)	(3.87)	(5.30)	(3.29)	(3.18)
Education Controls		No	Yes	Yes	No	Yes	Yes
Occupation Controls		No	No	Yes	No	No	Yes
Adjusted R-Squared		0.18	0.25	0.32	0.14	0.23	0.32
F(Literacy)		*4.02	0.56	0.26	*11.33	*4.82	2.42
F(Numeracy)		*4.02	*12.71	*7.69	*19.29	*5.94	*5.06
F(All Skills)		*58.10	*15.36	*8.82	*51.29	*14.83	*9.40

By Age Group		Ages 25-34			Ages 35+		
		1	2	3	1	2	3
Literacy	Proficient	819.39	448.71	272.26	584.09	190.52	44.81
		(3.17)	(1.76)	(1.09)	(3.19)	(1.08)	(0.27)
	High	1428.84	924.06	667.95	1166.49	529.80	336.41
		(3.77)	(2.48)	(1.84)	(3.97)	(1.87)	(1.26)
Numeracy	Proficient	392.99	50.09	-8.99	1483.55	895.38	655.55
		(1.48)	(0.19)	(-0.04)	(7.79)	(4.82)	(3.71)
	High	1489.99	917.65	846.59	2622.20	1716.88	1362.48
		(3.69)	(2.30)	(2.18)	(8.54)	(5.72)	(4.78)
Education Controls		No	Yes	Yes	No	Yes	Yes
Occupation Controls		No	No	Yes	No	No	Yes
Adjusted R-Squared		0.14	0.20	0.25	0.19	0.27	0.35
F(Literacy)		*7.69	*3.11	1.69	*8.65	1.75	0.92
F(Numeracy)		*7.15	*3.75	*3.79	*45.22	*18.80	*12.52
F(All Skills)		*28.49	*8.79	*6.31	*84.11	*23.90	*14.44

By Place of Birth		US-Born			Foreign-Born		
		1	2	3	1	2	3
Literacy	Proficient	434.41	79.05	-19.60	888.69	343.41	198.49
		(2.73)	(0.50)	(-0.13)	(1.79)	(0.71)	(0.42)
	High	865.52	290.49	138.89	1930.91	623.96	484.78
		(3.50)	(1.19)	(0.60)	(2.37)	(0.78)	(0.63)
Numeracy	Proficient	1345.62	996.82	747.88	1444.58	227.29	-50.56
		(8.16)	(6.17)	(4.87)	(2.92)	(0.44)	(-0.10)
	High	2810.84	2237.41	1881.04	1578.98	202.24	-253.74
		(10.78)	(8.76)	(7.74)	(2.02)	(0.25)	(-0.32)
Education Controls		No	Yes	Yes	No	Yes	Yes
Occupation Controls		No	No	Yes	No	No	Yes
Adjusted R-Squared		0.17	0.23	0.31	0.13	0.23	0.29
F(Literacy)		*6.57	0.74	0.35	*3.11	0.38	0.21
F(Numeracy)		*63.16	*40.18	*30.42	*4.54	0.10	0.06
F(All Skills)		*104.40	*42.34	*29.20	*13.90	0.53	0.11

Table 7: Literacy, Numeracy, and Earnings Relationships by Educational Attainment						
	High School or Less		**Some College**		**BA and Above**	
	1	2	1	2	1	2
Literacy						
Proficient	528.73	323.65	158.15	10.35	111.79	26.32
	(3.15)	(2.00)	(0.60)	(0.04)	(0.33)	(0.08)
High	734.68	303.90	497.88	159.81	536.63	443.11
	(1.92)	(0.82)	(1.14)	(0.39)	(1.26)	(1.12)
Numeracy						
Proficient	789.58	628.08	407.17	355.15	797.85	461.92
	(4.00)	(3.31)	(1.43)	(1.35)	(2.61)	(1.63)
High	1044.04	828.82	208.43	306.19	1917.72	1366.98
	(2.36)	(1.96)	(0.41)	(0.65)	(4.62)	(3.52)
Occupation Controls	No	Yes	No	Yes	No	Yes
Adjusted R-Squared	0.13	0.21	0.09	0.21	0.07	0.23
F(Literacy)	*5.29	2.00	0.65	0.09	1.10	1.13
F(Numeracy)	*8.63	*5.90	1.07	0.91	*10.76	*6.53
F(All Skills)	*18.23	*8.81	2.03	1.00	*14.51	*9.35

Table 8: Literacy, Numeracy, and Earnings Relationships by Occupation

	Managers, Senior Officials, and Professionals		**Technicians and Associate Professionals**		**Clerical and Sales Workers**	
	1	2	1	2	1	2
Literacy						
Proficient	213.11	-0.16	507.42	373.63	127.54	54.05
	(0.63)	(0.00)	(1.74)	(1.29)	(0.72)	(0.30)
High	834.44	623.54	870.76	533.84	13.12	-37.64
	(1.91)	(1.43)	(1.87)	(1.14)	(0.04)	(-0.11)
Numeracy						
Proficient	1050.81	854.38	426.68	266.50	283.39	215.73
	(3.31)	(2.67)	(1.46)	(0.92)	(1.40)	(1.07)
High	2292.84	1932.44	422.37	143.65	25.10	-241.27
	(5.30)	(4.42)	(0.74)	(0.25)	(0.07)	(-0.66)
Education Controls	No	Yes	No	Yes	No	Yes
Adjusted R-Squared	0.15	0.18	0.11	0.14	0.10	0.13
F(Literacy)	2.33	2.06	2.17	0.98	0.30	0.08
F(Numeracy)	*14.09	*9.82	1.08	0.43	1.11	1.27
F(All Skills)	*23.32	*15.07	*3.93	1.41	1.18	0.88

	Craft and Related Trade Workers, Machine Operators and Assemblers			Laborers and Service Workers	
	1	2		1	2
Literacy					
Proficient	41.27	-22.83		527.07	335.57
	(-0.14)	(-0.08)		(1.91)	(1.20)
High	-71.57	-137.09		16.78	-256.63
	(-0.11)	(-0.21)		(0.03)	(-0.45)
Numeracy					
Proficient	1011.48	931.51		-230.21	-236.52
	(3.23)	(2.93)		(-0.70)	(-0.72)
High	-639.24	464.72		135.58	-185.99
	(-0.93)	(0.67)		(0.21)	(-0.28)
Education Controls	No	Yes		No	Yes
Adjusted R-Squared	0.08	0.11		0.10	0.12
F(Literacy)	0.03	0.02		2.25	1.34
F(Numeracy)	*5.24	*4.39		0.40	0.26
F(All Skills)	*4.08	*2.80		1.20	0.79

Appendix Table 1: Education by Age and Gender

Education Level	Males	Females	Ages 25-34	Ages 35+
High-School Dropouts	10.47%	9.87%	9.77%	10.28%
High-School Graduates	41.72	37.95	36.59	40.77
Some College	17.26	20.89	21.43	18.43
College Graduates	17.78	18.77	21.19	17.34
Above BA	12.78	12.53	11.01	13.19

Appendix Table 2: Occupation Distribution by Age and Gender

Occupation	Males	Females	Ages 25-34	Ages 35+
Senior Officials and Managers	14.07%	8.64%	6.83%	13.08%
Professionals	19.46	25.47	23.23	22.05
Technicians	15.56	19.87	16.86	17.92
Clerks	3.81	11.16	7.23	7.41
Service Workers	12.08	19.84	18.98	14.72
Skilled Agricultural/Fishery Workers	1.85	0.15	1.32	0.93
Craft and Related Trade Workers	16.12	1.72	8.46	9.41
Plant and Machine Operators	8.89	2.97	4.38	6.62
Laborers	3.89	1.41	3.62	2.36
Sales Workers	4.27	8.76	9.09	5.50