# The Educational and Cognitive Transformation of Social Opportunity and Inequality: Credentials, Cognition, and C-status

*David Baker, Karly Ford, Liang Sun, Yuan Chih (Andy) Fu, Frank Fernandez, and Mark Umbricht*

Most research on the outcomes of educational inequality is limited in its ability to weigh in on the merits of human capital or credentialing theory because many survey datasets do not contain rigorous measures of adult cognitive skills, along with measures of income, occupational outcomes and educational attainment. This project investigates these relationships among cohorts of adults in 2012 using a sample of workers drawn from the PIAAC dataset. We focus on two research questions: ***What is the impact of cognitive job skills and educational credentials on occupational outcomes for cohorts of American adults? And, to what degree is this joint impact reflected in the differentiated structure of U.S. occupations?***

We model the data using multinomial logistic and OLS regression strategies. We also examine the joint effects of education and cognitive ability (C-status) on labor market outcomes by building a structural equation model. We find that:

1) Education and cognitive skills have *independent* effects on monthly earnings and occupational prestige.
2) Education and cognitive skills have *joint* effects on monthly earnings and occupational prestige. We argue that the joint effects of education and cognitive skills can be considered as a single construct; **C-status**. Rather than studying skills and education credentials separately, a person's C-status is a more robust predictor of labor market outcomes.
3) Findings one and two can be viewed within the current landscape of labor market. Workers who have earned advanced education credentials ***and*** demonstrate high proficiency in cognitive skills hold occupational positions that require higher order skills (frequent reading, writing and managing). In other words, workers with high C-status are more likely to be working in high prestige occupations that require skilled labor than their peers with just high skills or just advanced educational credentials.

This work makes theoretical, empirical, and policy contributions to the literature about education credentials, cognitive skills and economic outcomes. Using PIAAC's robust psychometric measure of adult skills, we create a new construct, C-status, to measure the combined effects of cognitive skills and credentials. C-status operates as a joint measure in much the same way as socioeconomic status operates as a joint measure of education, occupation and income. While each variable in socioeconomic status has independent effects on a person's social and economic wellbeing, the combined measure of all three gives a better picture of how the variables operate jointly. In the same way, C-status measures the joint effects of cognitive skills and education credentials. We show that the labor market is organized by C-status – education and cognitive skills operate jointly and C-status is a better predictor of monthly earnings and occupational prestige than either variable alone. This empirical contribution sheds new light on theories that isolate education credentialing *or* human capital skills as the important predictor of labor market outcomes. We hope to bolster new theories that consider how education credentials and cognitive skills operate jointly.

The C-status perspective presents a number of policy implications for both the development of education and labor market policies. It also presents implications for policy aimed at the lessening of social and economic inequalities.

# Education and Work in the 21st Century: Credential Inflation or Transformation?

*Frank Fernandez and Mark R. Umbricht*

Many people argue that education no longer guarantees a good job. They argue that the college degree is the new high school diploma. We refer to this idea as "credential inflation." Additionally, some scholars have argued that employers increasingly use technology in the workplace to pay less for workers with higher levels of education— a process called "digital Taylorism." However, other studies suggest that as the overall level of education increased, employers made jobs more cognitively complex to incorporate a more highly educated and skilled workforce. We used the unique nature of the 2012 Program for the International Assessment of Adult Competencies (PIAAC) dataset and its precursors—the 1994 International Adult Literacy Survey (IALS) and the 2003 Adult Literacy and Lifeskills (ALL) survey—to test the relationships between education, cognitive skills, job tasks, the use of technology, and labor market outcomes over time.

*Effects of Education on Earnings*

- Years of education had larger, positive effects on earnings in 2012 compared to 2003; Literacy was also significantly related to earnings in both years.
- In 2012, years of education and the use of Information Communication Technology (ICT) at work had positive, statistically significant effects on earnings.

*Likelihood of Being Employed*

- Regression analyses suggested that for each additional year of education, Americans were 15% more likely to be employed in 1994 and 14% more likely to be employed in 2012; Literacy was also positively related to employment (estimates were statistically significant).

*Likelihood of Being a Supervisor*

- For each additional year of education, Americans were 20% more likely to be a supervisor in 1994 and 11% more likely to be a supervisor in 2012 (estimates were statistically significant).

*Likelihood of Performing Job Tasks*

- Between 1994 and 2012, people with similar levels of education were more likely to complete complex job tasks "less than once per week".
- Years of education and literacy skills were both positively related to the frequency with which workers perform complex job tasks (estimates were statistically significant).

**Summary**

We found little evidence to suggest that as Americans became increasingly educated, years of education were less valued in the labor market over time. Because use of ICT was positively related to income, we refuted the idea that employers used technology to deskill jobs and lower wages. We found that as aggregate levels of education increased between 1994 and 2012, people with similar levels of education were more likely to perform complex job tasks in 2012.

**Recommendations**

Policymakers and practitioners should focus on (a) increasing access to higher education; (b) strengthening the relationship between education and cognitive skills; (c) developing a better understanding of the effects of education and the changing nature of work in the 21st century.

# Social Background and Numeracy Skill Levels Among College Graduates: Social Mobility or Social Reproduction?

*Karly Ford and Mark Umbricht*

While empirical research on first generation college students has tracked how students move into and through institutions, researchers rarely report on post-graduation outcomes of first generation students. By the time they graduate, first generation college students are considered part of a monolithic category of "college graduates." This is for good reason: most theoretical and empirical work in sociology and education suggests that a college degree mitigates the early (dis)advantages of social origins. This project tests the assumption that first generation and multi-generation college graduates are indistinguishable across skill and labor market outcomes. We ask: ***Is there a difference in numeracy scores between first-generation college graduates and multi-generation college graduates? Also, is college graduate generational status related to employment outcomes after controlling for numeracy score?***

The PIAAC data provide a rich array of interesting labor market outcomes to investigate. We compared first and multi-generational college students on a number of measures, including monthly earnings, whether or not they were employed, the occupational prestige of the job they held and whether or not their job matched the major they studied in college. We employed multivariate ordinary least squares (OLS) and logistic regression modeling techniques. Our findings are as follows:

1) First generation and multi-generation college graduates have similar labor market outcomes in terms of monthly earnings, employment, occupational prestige and rates of holding a job that matches their college major.

2) However, we find significant differences in the literacy and numeracy scores of college graduates who are first generation and those who have a college educated parent. Multi generation college graduates outperformed their first generation college graduate peers by large margins on assessments of numeracy.

While first generation college graduates enjoy access to many of the same labor market outcomes of their multi generation college graduate peers, these two groups are not indistinguishable. First generation college graduates lag behind in measures of numeracy. This finding contributes to a more complicated picture of universities, not solely as places that confer middle class advantages, but as places that are themselves stratified and produce stratified outcomes. This work provides some empirical support to the recent scholarship that has begun to describe the ways that universities are stratified by class, both between and within universities (Mullen 2012; Armstrong & Hamilton 2013; Carnavale 2013). This emerging line of higher education research adds nuance to the post-college conversation: college may not be the great equalizer. Having parents with a college degree is a social advantage that is associated with higher numeracy scores for students in kindergarten through secondary school. Our work suggests that those numeracy skill differences persist after college and into adulthood, even among college graduates. This work has some early implications for policy. It supports expanding to higher education the equity agenda that shapes funding and assessment decisions in the K-12 sector. Universities that close the achievement gap between first and multi-generation graduates should be identified and rewarded.

# Literacy and Numeracy Skills of Second-Generation Young Adults: A Comparative Study of Canada, France, Germany, the United Kingdom and the United States

*Jeanne Batalova and Michael Fix*

This paper employs data from the 2012 Program for the International Assessment of Adult Competencies (PIAAC) to examine the characteristics and competencies of young adults between ages 16 to 34 by immigrant generation. The analysis examines results in five countries that have received substantial numbers of immigrants over at least the last 50 years: Canada, France, Germany, the United Kingdom, and the United States. First- and second-generation young adults (i.e., those born abroad and those born in the host country to foreign-born parents, respectively) account for substantial shares of all young adults: ranging from roughly 30 percent in the United States and in the United Kingdom to about 40 percent in Canada. **We compare the first- and second generations' literacy and numeracy skills to those of the native-born young adults from native families**, defined here as the third/plus generation. We find that:

- Across all five study countries first-generation young adults substantially lagged behind the literacy and numeracy skills of the second and third/plus generations. Young immigrant adults in Canada had the highest literacy and numeracy scores; those in France and the United States hadthe lowest scores.
- A substantial share of young immigrants—more than a third in Germany, the U.S., and France—lack basic literacy skills, which means that they have only basic vocabulary knowledge and can only work with simple, short texts of written information. More than two in five immigrants in France, the U.K., and the U.S. are low proficient in numeracy and are only able to solve simple mathematical operations involving counting, sorting, and basic arithmetic.
- Literacy and numeracy scores are substantially higher among second-generation young adults across all five countries, with scores essentially equaling those of the third/plus generation for the United States, Canada, and the United Kingdom. While the second generation performs much better than the first, the second generation generally score only at or below "proficient."
- Germany is the only country where second generation scores do not approximate the third; although there is notable intergenerational progress between the first and second generations there, as well as in the other four study countries.
- Numeracy scores in Germany are as high as literacy scores: All other countries' average numeracy scores are lower than their literacy scores. Numeracy is held to be a particularly good predictor of individual mobility.
- Comparatively strong average literacy and numeracy scores are broadly achieved across generations by Canada and by the third-generation young adults in Germany.

Viewed, somewhat speculatively, through a policy lens, one could hypothesize from these results that the five study countries have made strides along one or more of the three policy dimensions: successful immigrant admission, integration of immigrants and their children, and skills development. It appears that integration mechanisms are working rather smoothly in Canada, the United States, and France, but that skills development frameworks lag in the latter two countries. The U.K. may face both integration and skills development challenges. At the same time, skills development is more advanced in Canada and Germany. But it could be argued that integration lags in Germany. These hypotheses have to be tested by examining the contributions of gender, race and ethnicity, parental education, and host country's language skills to young adults' literacy and numeracy outcomes across generations.

In terms of future research questions, our findings point to the need to examine policies and programs across the five study countries as well as other countries to understand how governments and service providers can successfully improve skills and workforce readiness of immigrant-origin young adults to ensure their full integration and participation in the economy and society.

# Reconstructing the Evolution of the American Supply of Cognitive Skills: A Synthetic Cohort Analysis

*T. Scott Murray, Richard Shillington, and Marilyn Binkley*

The markets model of skill that underpins the 1994 International Adult Literacy Survey (IALS), the 2003 Adult Literacy and Life Skills Survey (ALL) and the 2011 Program for the International Assessment of Adult Competencies (PIAAC) adult skill assessments includes elements of the occupational and social demand for skill, the supply of skill that individuals can muster to meet these demands and a series of markets, including the labor market, that match the skills of individuals to the extant demand. At any given point in time it is an open question as to whether the available supply of skill is adequate to satisfy the economic demand for skill. Even when skill supply and demand are roughly in balance inefficiencies in the market for skills result in significant numbers of workers with skills above or below the level demanded by their job. The labor market creates differential outcomes for individuals, social institutions and nations that themselves create different levels of incentives to acquire and maintain skills.

Policy makers have long focused most of their efforts on generating new skill supply and on creating credentials that are reliable signals of skill, implicitly assuming that markets would put whatever they created to productive economic use.

Our analysis used statistical matching to create synthetic individuals that look as if they participated in both the 2003 ALL and 2011 PIAAC studies. This linked file is used to approximate the distribution of literacy skill gain and loss in the U.S. and Canada and, through regression analysis, **to explore the factors that were associated with skill gain and loss over the period**.

- A cross-sectional comparison revealed that average skill levels did not rise as expected given the rapid increases in educational attainment levels achieved over the period.

- Analysis of the synthetic cohort data reveals that while adults of all backgrounds both gained and lost literacy skill over the period, enough adults lost skill to result in a decline in average scores.

- A regression analysis of the factors that are associated with skill gain and loss reveals that the cognitive demands of the job play an important role. Adults in jobs that require the application of cognitive skills in non-routine ways tended to gain skill whereas adults in jobs that only demanded the routine application of procedural knowledge lost skill.

These findings suggest that public policy may have to pay more attention to the demand side of the labor market. More pointedly, employers may not create the knowledge and skill intense jobs that are needed to compete in global markets without some inducement from government.

# Earnings and Employment Benefits of Adult Higher Education in Comparative Perspective: Evidence Based on PIAAC

*Richard Desjardins and Jeongwoo Lee*

Adult learning systems are increasing in importance in today's modern society, and the degree of *openness* of Higher Education (HE) systems to non-traditional students, or alternatively Adult Higher Education (AHE), is an important component of advanced adult learning systems. In this study, *openness* of HE is defined as the proportion of adults who attained their HE qualification beyond the normative age (i.e. beyond the age in which students would have attained their highest qualification had they followed the normative path). This signifies the degree of flexibility and diversity in HE provision structures, for example, in terms of access, admission and selection policies, as well as capacity. AHE is an established phenomenon in many countries but there are sharp differences in the extent to which HE systems are open to adults beyond the normative age. For example, in some countries the HE system remains relatively *closed* by effectively limiting access to *equivalent* qualifications for adults who did not follow the normative path, and instead focus HE provision on younger cohorts as they follow the normative path. Such differences may be an important source of variation that explains economic success and other outcomes in different countries. The merits of AHE have been scrutinized in a number of countries at the micro level in terms of labor market success such as earnings and employability. Such benefits are important, especially in the context of public financing.

The PIAAC dataset allows for a comparative overview of the earnings and employment benefits of AHE at the micro level as well as a glimpse on the possible macro level implications such as overall employment rates and the adult skill profile. Using the PIAAC dataset, this paper: **reports the incidence of adult higher education in comparative perspective; compares earnings and employment differentials of traditional vs non-traditional students; and, finds correlations at the country level between the openness of HE systems to non-traditional students and the employment rate as well as cross-national adult skill profiles**.

Four key findings are as follows. First, the PIAAC data confirm what other studies have shown at the micro level, that older HE graduates do, on average, have better employment and earning outcomes than their counterparts with no HE qualifications. Second, the study shows that there is no systematic pattern at the micro level to suggest that older HE graduates experience less favorable labor market outcomes compared to those of traditional age students. This depends on type and level of qualification as well as country. Third, earnings boosts are observed regardless of literacy proficiency levels or socio-economic background. Fourth, the study found strong correlations between the proportion of older HE graduates and the overall employment rate as well as skill profiles at the macro level.

These findings suggest that higher qualifications promote labor market attachment of adults, productivity and overall employment across the skill proficiency and socioeconomic spectrum. They also suggest that HE systems catering to the needs of adults over their lifespan may play a role in boosting the skills measured in PIAAC, or alternatively mitigating their loss. The interaction of AHE with skill loss as people age can be explored further with PIAAC. Other avenues for further research might involve more detail on who pursues AHE (can be done with PIAAC) and why including a more detailed contextualization of the US experience; identifying what constitutes flexible and diverse HE provision structures that cater to the needs of adults and the labor market; and, comparing the role of both labor market and education institutions and policies in enabling or constraining AHE for labor market purposes.

# Examining Gender Differences in the Mathematical Literacy of 15-Year-Olds and the Numeracy Skills of the Age Cohorts as Adults

*Alka Arora and Emily Pawlowski*

Patterns of gender disparities in science, technology, engineering, and mathematics (STEM) fields are seen at various stages, from early education to secondary school through college and into the workforce. These disparities have often been documented in international school assessments and in labor force studies. This study uses data from the two assessments—mathematical literacy in the Program for International Student Assessment (PISA) and numeracy in Program for the International Assessment of Adult Competencies (PIAAC) —to look at the skills and characteristics of a group of 15-year-old students and their age cohort as 23-to-25-year-old adults. **Combining PISA and PIAAC allows one to see the progression of gender differences in mathematics skills from the 15-year-old students in PISA to the cohort of 23-25 years old young adults in PIAAC**.

- In general, there is a fairly close correlation between countries' mathematics performance in PISA 2003 and in numeracy in PIAAC 2012, when looking at the relevant age cohort in PIAAC (23- to 25-year-olds).
- The gender gap in mathematics performance of the cohort of 15-year-olds in PISA 2003 either stayed the same in PIAAC 2012 (when those in the cohort were 23 to 25 years old) or increased. Approximately half of the countries showed an increase in the gender gap, with Finland and United States showing the largest increase.
- Within the total PIAAC population, the size of the gender gap in numeracy increases as age increases. The 16 to 24 age group shows the least number of significant differences between males and females within countries.
- In most countries that participated in PISA 2003, male students were more engaged in and had more positive attitudes toward learning mathematics than females, although most of these gender differences were small.
- In all but one country, more females than males ages 23-25 had completed a university degree. However, many more males than females earned a degree in the STEM-related areas of science, engineering, mathematics, and computing. More females than males choose non-STEM areas and the females who did choose STEM areas more often chose the areas of education sciences or health and welfare.
- Female adults in 10 out of 16 countries in the study used their numeracy skills at home less frequently than males did. Females in 8 of the 16 countries in the sample used their numeracy skills at work less often than males; the Netherlands had the highest gender difference in adults' use of numeracy skill at work.
- In most countries, there was no gender difference in adults' readiness to learn new ideas and information. The United States and Japan were the only two countries in which females showed slightly less readiness to learn new ideas or information than their male counterparts.

These findings suggest that there is a still a long way to go toward gender equity in the STEM fields. Educators at various levels need to understand these differences and work with their female students to improve their attitudes and engagement with STEM fields. It is also important for colleges and universities to create resources and policies to encourage female students to choose and complete their major area of study in the STEM fields.

## Literacy and Fertility Across OECD Nations

*Jane Seymour, Rosemary Frasso and Ian Bennett*

Understanding the processes that influence birth rates for individuals and populations is of great interest to the medical, public health, and demographic fields as well as national and international policy makers. A strong link between an individual's literacy skills and their adult health has been documented, however the relationship between literacy and women's reproductive health remains understudied. The little work that has been done has provided evidence for an association between literacy and total childbearing in the developing world, as well as between literacy and likelihood of grand multiparty (five or more births to one woman) in the U.S. Another limitation of past research is the lack of attention to the mechanisms by which literacy might work to impact childbearing. In the current research we sought to assess: **1) the relationship between literacy and childbearing across OECD and partner nations, and 2) the potential mediating and moderating effects of literacy on self-reported health, a pre-disposing factor for total number of children.** If a mediator, literacy would at least partially account for any relationship seen between health and childbearing. If a moderator, the magnitude of association between health and childbearing would change in a non-linear manner based on levels of literacy and other independent variables (interaction). Evidence of mediation and/or moderation could support distinct explanations for how policies impacting literacy might influence childbearing.

We included all women not missing data on PIAAC literacy score, childbearing, or other covariates from 18 OECD and partner countries, including the United States. Across these countries, average PIAAC literacy score ranged from 250 (Spain) to 295 (Japan). Average total childbearing ranged from 1.2 (Russian Federation) to 1.8 (United States). For self-reported health, when the excellent, very good, and good categories were collapsed, between 45% (Republic of Korea) and 88% (the Czech Republic) fell into this category. Average age in the sample ranged from 39 (Ireland) to 42 (Italy and Japan).

Consistent with previous work there was a negative relationship between literacy and total childbearing (increasing literacy is associated with lower childbearing), in all countries except the Russian Federation. Furthermore, self-reported excellent/very good compared with good health was associated with increased childbearing and self-reported fair/poor compared with good health was associated with decreased childbearing. For each country, one of these two relationships (between excellent/good or fair/poor health and childbearing) was significant.

We found evidence that the relationship seen between self-reported health and childbearing varies in magnitude based on literacy status (moderation) in only two out of 18 countries (Slovak Republic $p=0.042$ and Spain $p=0.024$). In contrast, we found evidence that literacy explains (mediates) the relationship seen between self-reported health and total childbearing in all countries except for Norway, Denmark, and Belgium.

In summary, there was a consistent and significant negative relationship between literacy and the number of children per woman across all 18 OECD and partner countries. Additionally, these findings suggest that literacy plays a mediating rather than a moderating role between predisposing factors, in this case self-reported health, and total childbearing.

These findings provide additional support for literacy as a key variable influencing health outcomes at the national and international level. The place of literacy as an outcome of social and educational policy is critical to bear in mind as the processes influencing demographic changes are considered and interventions are developed to address any of these interrelated factors.

# Understanding the Basic Reading Skills of U.S. Adults: Reading Components in the PIAAC Literacy Survey

*John Sabatini*

Recent results paint a troubling portrait of the literacy skills of U.S. adults. Equally troubling is that these skills have remained relatively unchanged when compared to results from previous years of U.S. adult surveys, while other countries have been showing improvement, especially among adults with low basic skills. Through a recent survey's deeper exploration of the most foundational component skills, we have richer information from which we can gain insights and draw implications for policy, as well as for learning and instruction for adults who score at the lowest levels of proficiency.

The ability to read fluently and for understanding – to be able to learn from text – is perhaps the most important foundational skill for U.S. adult citizens' health, well-being, and social and economic advancement. It is not only an essential skill when competing for jobs in the 21st century workforce, but is also a gateway to lifelong learning, education and training.

Reading components results help us to understand what adults with scores at or below Level 1 can and cannot do. Can they identify the meaning of high-frequency vocabulary words in print? Can they evaluate the meaning of single sentences? Can they read for local meaning in simple passages?

In this study, we describe **a) the reading component measures; b) results from four English and two non-English speaking countries who took the paper-based route of the PIAAC survey (including the reading components measures); and c) implications of those findings for policy and practice.**

- General: The U.S. below and at Level 1 groups consistently scored below the other English speaking countries in the sample, as well as below Spain and Italy. In most analyses, by Level 2, the U.S. results are comparable to other countries. Most adults at Level 3 were able to answer nearly all reading component items correctly.
- Reading Components Rate: With respect to time to complete the task sets, the U.S. was not disproportionately slower than the other countries in the sample. In general, differences in accuracy of performance are all reflected in speed or rate for completing task sets across the entire ability distribution. This suggests that fluency or automaticity of component skill processing is part of the underlying foundation of literacy for most adults.
- Nonnative Speakers of the Test Language: A significant proportion of the difference between the U.S. and the other countries in the six country sample could be attributed to the relatively poorer performance of the nonnative English speaking subgroup in the U.S. sample. The nonnative speakers in the U.S. sample generally performed lower than nonnative speakers in other countries in the sample. In general, nonnative speaker groups in countries scored lower than native speakers.
- Native Speakers of Test Language only: Comparing only native speaking adults across the sample, the U.S. results are comparable to the six country averages. This pattern still demonstrates weaknesses in reading component skills for at or below Level 1 U.S. adults (as well as in the other countries).

# Exploring Response Patterns in Problem-Solving Items Using Process Data: Insights from Log Files of Problem Solving in Technology-Rich Environments (PS-TRE) in PIAAC

*Qiwei He and Matthias von Davier*

**Focus:** This paper draws on process data from log files recorded in the PIAAC problem solving in technology-rich environments (PSTRE) program to address the question of how sequences of actions recorded in problem-solving tasks are related to task performance. **We investigated the utility of behavioral process data for predicting differences in task performance**. More specifically, we separated the test takers into two performance groups (correct and incorrect) in one PSTRE item[1], extracted action sequences, and identified the key action sequences that were significantly associated with task completion.

**Objectives:** The purpose of this study is twofold: first, to extract and detect robust sequential action patterns that are associated with success or failure on a problem-solving item, and second, to compare the extracted sequence patterns among selected countries.

**Methods:** A total of 3,926 test takers from three exemplary countries (the United States, the Netherlands, and Japan), consisting of 2,754 individuals (70.1%) in the correct group and 1,172 (29.9%) in the incorrect group, were included in the study. Motivated by the methodologies of natural language processing and text mining, we disassembled the test takers' process data into small action sequences and applied feature selection models to identify the discriminant action sequence patterns by different performance groups at a variety of aggregate levels.

**Results:** The results showed that action sequence patterns significantly differed by performance groups and were consistent across countries. Among the robust indicators that we noticed were that the correct group had a better understanding of the sub-goals of different environments and were more likely to recover from initial errors in the problem-solving process. Conversely, respondents in the incorrect group appeared to have only a relatively vague idea about what was expected in the item and were more likely to show hesitative behaviors, such as clicking on the Cancel button multiple times and using the Help function.

**Conclusion and Implications:** In conclusion, with increasing use of computer-based assessments, process data play an increasingly important role in tracking test takers' thinking and action sequences. This pilot study presents what we think is a promising method to analyze process data and extract robust sequence features that are informative for differentiating between performance groups.

[1] Since the action sequences are special per problem solving item, we focused on one PSTRE item to illustrate how we tracked test takers' problem solving process using process data.