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Introduction

The increased reliance on diversity and teamwork in the workplace has led to a renewed interest in "soft skills" among policy makers and educators concerned with preparing the workforce for the jobs of the future (Quintini, 2014). Further, workplace learning scholars (Billett & Nobel, 2017; Eraut, 2007; Skule, 2004) argue that cooperation/collaboration will enhance individual learning and development of a variety of technical skills, especially for jobs that require coordinating with others. In response to these assumptions, many education programs have adjusted the curriculum to help students develop the skills and dispositions to effectively engage and interact with others in the workplace (International Labour Office, 2010). However, there is mixed evidence about the relationship between cooperation/collaboration and teamwork at work and cognitive skills that are vital to work today. For example, Skule (2004) suggests team work contributes to the maintenance as well as the learning of cognitive skills, while there is evidence that teamwork results not in learning, but in interpreting information in ways that confirm pre-existing beliefs and assumptions (Beckman, 1990). Additionally, faulty dynamics in teams, such as those that correspond to team dysfunction, may inhibit learning (Marsick & Watkins, 2015). The Program for the International Assessment of Adult Competencies (PIAAC) data set represents a rare opportunity to examine these phenomena on a national scale. Therefore, the purpose of this paper is to investigate the extent to which cooperation/collaboration at work and sharing work-related information considered here as two distinct activities, is associated with cognitive skills, as measured by the PIAAC study.

Literature Review

Rapid change in technology and the economy has sparked renewed interest among policy makers and human resource practitioners and scholars in the skill sets that contribute to individual performance and career security (International Labor Office, 2010). Recently, workplace learning scholars (Kim, Hawley, Cho, Hyun, & Kim, 2015; Marsick & Watkins, 2014; Rausch, 2013; Skule, 2014) have turned their attention to understanding the characteristics of jobs that demand a high degree of learning among the job-holders, sometimes referred to as learning-intensive jobs (Skule, 2014). Most of the related research found shows or assumes a correlation among cooperation/collaboration, information sharing, and workplace learning (Kilgo, Sheets, & Pascarella, 2015; Ku, Tseng, & Akarasriworn, 2013; Latham, Julien, Gross, & Witte, 2016; Steensma, 1996). Given the important relationship between skills and employment in today's economy, a deeper understanding of the structural factors in the workplace that foster the learning and maintenance of relevant work-related technical, cognitive, and so-called non-cognitive, social skills (OECD, 2009) is required.

The relationship between job characteristics and skill acquisition

Literature on the learning organization (Watkins & Marsick, 1993) as well as the learning intensity of jobs (Skule, 2014) has helped to delineate some of the characteristics of jobs that are cognitively demanding and thereby press job-holders to continuously learn (Billett, 2004). This literature suggests that the characteristics of jobs that demand a high measure of learning fall largely in four areas, including: (a) the task characteristics of jobs, such as autonomy and discretion (Kim, et al., 2015, Marsick & Watkins, 2014; Rausch, 2013); (b) the knowledge characteristics of jobs, novelty and experimentation for example (Yang, Marsick and Watkins, 1998; Rausch, 2013); (c) the social characteristics of jobs, including collaboration and inquiry

(Marsick & Watkins, 2014; Rausch, 2013; Skeul, 2014; Yang, Marsick, & Watkins, 1998); and (d) the contextual characteristics of jobs, such as exposure to change and management support for learning (Kim, et al., 2015, Marsick & Watkins, 2014; Skule, 2014;).

In addition to fostering skill acquisition, de Grip & van Loo (2002) found that demands for learning on the job also contribute to individual differences in the naturally occurring skill decline in adulthood. Specifically, the authors found that skill decline related to maturation may be offset by individual differences in whether and how cognitive skills are used at work. Indeed, the PIAAC assessment of US workers bore out this hypothesis (OECD, 2013). Workers who reported that they were overeducated for their current position scored lower in the performance on the PIAAC skills when compared to workers in their age and educational cohorts who reported that they engaged in work tasks that were on par with or exceeded their current level of education or degree (OECD, 2013). Taken together, these findings suggest that there are certain job characteristics that help workers to develop and maintain the cognitive skills as measured by PIAAC.

The PIAAC background questionnaire (OECD, 2009) included questions based on many of the structural characteristics of jobs that research suggests contribute to learning and skills maintenance through work and therefore there is opportunity to study these variables in relationship to the performance of PIAAC competencies on the individual level. While acknowledging that the literature identifies multiple structural factors, our research focuses on the social characteristics of learning intensive jobs.

Yang, et al. (1998) found jobs that require team learning build collaborative skills, and Rausch's (2013) found that feedback on the performance of tasks fosters individual learning; both findings correspond to the BQ questions related to how often respondents learn from peers

and supervisors (D_Q13a) and are required to teach others (F_Q02b). Further, the learning potential of jobs is enhanced when the job requires a high measure of social interaction, including a high degree of exposure to the demands of others (Skeul, 2014), inquiry and dialogue (Yang, et al., 1998), and openness and accessibility to people (Marsick & Watkins, 2014). Engagement outside of ones' organization, including working across boundaries of many kinds (Marsick & Watkins, 2014) and extensive professional contacts (Skeul, 2014) were also found to foster a high measure of learning on the job. These variables are captured in the PIAAC BQ in questions such as how often do you: make speeches/presentations, sell products/services (F_Q02c,d); negotiate with people in and out of your firm (F_Q04b); and participate in discussions on the internet (G_Q05h).

Finally, several studies noted that the requirement to engage in informal and tacit communications on the job with both supervisors and co-workers also results in learning (Marsick & Watkins, 2014; Kim, et al., 2015). These requirements were not fully captured in the PIAAC BQ, however, discussions on the internet (G_Q05h) certainly qualify as informal and maybe tacit as well. We believe an examination of the data from the PIAAC survey may help in developing a more comprehensive understanding of the individual learning that is often *assumed* to result from participating in teamwork or being a part of an organization that emphasizes information sharing (Beckman, 1990).

Factors related to cooperation/collaboration and information sharing

At this point a closer examination of the relationship between the social characteristics of jobs that call upon workers to use social skills at work and cognitive skills as measured by the PIAAC competencies assessment is required. Though the workplace learning research has established a relationship between the social characteristics of jobs and the learning and

maintenance of skills, including cognitive, technical and social, there is limited research that explains specifically how social interactions, and specifically cooperation/collaboration and the sharing of information on the job leads to the development and maintenance of these skills. Nevertheless, there is some research that can inform the design of this study.

OECD research (Martin, 2018; OECD, 2001; 2015) has noted the broad impact of increased use of Information and Communications Technology (ICT) on organizational structures and human capital requirements in the new, knowledge economy (OECD, 2001). ICT is giving rise to new organizational environments and formats that require a broad range of technical and social skills. For example, new horizontal organizational formats enabled by ICT call for more cooperation across teams and levels in the organization (OECD, 2001, 2015). Horizontal structures and the resulting need for cooperation also require the widespread diffusion of information among a larger number of workers, which increases the importance of both social and cognitive skills among the workforce (OECD, 2001, 2015).

Yang and Maxwell (2011) reported that at the interpersonal level, concerns about power and potential use of information urges some to be skeptical of sharing with others (Constant, Kiesler, & Sproull, 2011). Yang and Maxwell (2011) speculated:

> In such cases, information can be viewed as a form of property, which when surrendered, exposes the individual to threats of loss of status within the organizational setting. In both positive and negative cases, individual predilections regarding information sharing may also interact with various organizational factors – such as competition and collaboration – that either hinder or foster information-sharing behavior. (p. 165)

Instances such as these show that even in environments purported to be collaborative or cooperative rather than competitive there are motivations for individuals to resist sharing information – which could lead to lack of learning or development at the individual level.

Regarding cooperation/collaboration as an organizational factor impacting the likelihood of good information-sharing practices, Kim and Lee (2006) argued that the centralization of information within an organizational environment is likely to diminish individual desires and capacities to share what they know. In short, people may be more likely to share information with others at work when they feel like they have the autonomy to choose when and how to share.

These findings are consistent with additional research exploring cooperation/collaboration in work environments. Sonnenwald (1995) and Sonnenwald and Pierce (2000) explored the concept of "contested collaboration," in which they argued individuals often only engage in cooperative behaviors to the extent that they are also able to advance their own interests and knowledge. Thomas and Perry (2006) explained, "Although information sharing is necessary for collaboration, it is not sufficient for it to thrive. Without mutual benefits, information sharing will not lead to collaboration" (p. 27).

Therefore, the ways in which employees interpret the mutual benefits of information-sharing within their work environment are extremely important to understanding collaborative behaviors. Five environmental factors impact workplace learning and transfer: supervisor support, supervisor sanctions, workload, opportunity to use information, and peer support (Russ-Eft, 2002). Together, these five factors indicate that employees are more likely to learn if they feel supported, understand their job, and maintain access to appropriate organizational resources. Likewise, Ellinger's (2005) research surfaced the importance of positive organizational factors such as "learning-committed leadership and management," "an internal culture committed to learning," "work tools and resources," and "people who form webs of relationships for learning" (p. 401). A lack of these factors, or the addition of structural barriers such as time and fast-paced

change, lead to diminished workplace learning (Ellinger, 2005). Finally, several studies have revealed differences in collaborative behaviors across industries (Sveiby & Simons, 2002), gender (Abramo, D'Angelo, & Murgia, 2013; Margrett & Marsiske, 2002), and worldview influenced by educational background (Garman, Leach, & Spector, 2006).

Based on this literature, the present study is focused upon examining two underlying propositions. First, that a high degree of cooperation/collaboration and information sharing at work leads to learning and improves or maintains adult competencies, as measured by PIAAC. Second, that the use of PIAAC skills at work reinforces the improvement and maintenance of those same skills.

Purpose Statement

The principal research question is: to what extent are respondents' level of cooperation/collaboration at work related to their literacy, numeracy, and problem solving in technology-rich environments skills? A secondary question will also be addressed: to what extent are respondents' level of information sharing at work related to their literacy, numeracy, and problem solving in technology-rich environments skills? The focused questions for this study are:

1. What is the relationship between *cooperation/collaboration* and *information sharing* and *literacy, numeracy, and PS-TRE skills* across industry sectors, controlling for gender and education?
2. How does the relationship between *cooperation/collaboration* and *information sharing* and *adults' use of specified skills* differ by industry, controlling for gender and education?

Methodology

The study used the 2012/2014 U.S. National Public Data Files. SPSS was used in conjunction with the IDB Analyzer in order to account for the plausible values of literacy, numeracy, and problem-solving in technology-rich environments (PS-TRE) and the sampling and replicate weights for accurate and unbiased parameter and standard error estimation. The details for the analysis procedures for each research question are listed below.

The first step was to run a model to examine the relationships in general – then industry-specific models were run. In order to narrow this exploratory study, not all industry sectors were included. Instead, sectors were chosen based on their identification by the U.S. Department of Labor's projections as those with the largest projected employment growth between 2014 – 2024 (Bureau of Labor Statistics (BLS), 2015). Those sectors were then cross-referenced with the sectors identified in the PIAAC survey (OECD, 2012). There were eight sectors which appeared on both the BLS list and the survey. They were: 1) Accommodation and food service (AFS); 2) Administrative and support service (AdSupp); 3) Construction; 4) Education; 5) Financial and insurance (FI); 6) Human health and social work (HHS); 7) Public administration and defense (PubAdmin); and 8) Wholesale and retail trade including repair of motor vehicles and motorcycles (WRT). These eight industries are projected to represent 60% of the workforce in 2024 (BLS, 2015). Therefore, this industry framework allowed us to access the PIAAC data for those industries that will employ a significant portion of the US population in the coming decade. The analysis examined the three models for each of these eight industries.

For each of the models only complete response cases were used. Some variables were recoded in order to create models which met reporting standards (an acceptable number of cases) and had statistical power. Details about how each variable was collapsed is below.

Research Question 1

For Research Question 1, a linear regression model was run for each of the eight industries as well as a model for all industries in order to do some comparative analysis. Each model included cooperation/collaboration (F_Q01b) and information sharing(F_Q02a). These two variables had five values along a frequency scale. In order to meet OECD's reporting standards (AIR PIAAC Team, 2019) and aide in the interpretation of results, the five responses were recoded in slightly different ways. The Cooperation/collaboration responses were collapsed to three values: "Up to ½ time" (combining "None of the time", "Up to ¼ time", and "Up to ½ time"), "More than ½ time" (unchanged) and "All the time" (unchanged). The reference value for Cooperation/collaboration was Up to ½ time. The information sharing responses were collapsed to two values: "Less than once a week" (combining "Never", "Less than once a month", and "Less than once a week/at least once a month") and "Once a week or more" (combining "At least once a week" and "Every day") with "Less than once a week" as the reference value.

Each model also included the demographic variables, Education level (derived from BQ_01a) and Gender (Gender_R) with Male as the reference value. The derived Education variable had six values aligned with U.S. education levels. However, because of the variance in respondents' education levels between industries the education level variable was additionally recoded in three different ways in order to maintain comprehension as well as increase the power of the results. Because of this the recoded variable is a reflection of the distribution of the education level of each industry. For instance, in order to increase the number of cases in the higher education levels in the Construction industry the highest recoded category includes Associates Degree, Bachelor's Degree, and Graduate Degree.

For four industries (Education, FI, HHS, PubAdmin) education level was recoded into two levels: with "No College Degree" and "College Degree" (originally Associates degree or higher) with "No College Degree" as the reference value, and categorized as More College Degrees. For three industries (AFS, AdSupp, Construction) it was recoded into four levels: "Less than High School" (unchanged), "High School/Equivalent" (unchanged), "Post-High School Certificate" (unchanged), and "College Degree" (originally Associates degree or higher) with "Less than High School" as the reference value, and categorized as Some College Degrees. Lastly, WRT was recoded into three levels: "Less than High School" (unchanged), "High School/Equivalent" (unchanged); and Post-High school education (originally Post-HS or higher), primarily because of the very low number of cases in the responses above a high-school level, with "Less than High School" as the reference value, and categorized as Fewer College Degrees. Table 1 shows the way in which Education was coded across industries while Table 3 shows the detailed distribution resulting from the recoding.

An alpha level of .05 was used to determine significance for each variable's relationship to the PIAAC competencies. Research question 1 was addressed using the following base model:

$$PIAAC\ Skills = \beta_0 + \beta_1 COLL + \beta_2 INFO + \beta_3 EDUC + \beta_4 GENDER + Residual$$

In this model PIAAC Skills denoted the predicted average values for the three PIAAC cognitive assessment scores: literacy (LIT), numeracy (NUM), and problem-solving in technology-rich environments (PSTRE). β_0 designated the intercept value of the PIAAC skills, while COLL reflected the frequency in which one reported to engage in cooperation/collaboration in the workplace. INFO was the extent to which one reported sharing

work-related information and EDUC reflected education level derived and coded as described above. Lastly, GENDER was included in the model as a binary response choice on the PIAAC survey. Residual is the error term in the model. Independent variables were considered to be significantly related to the dependent variable (PIAAC skills) at the alpha level of .05. This model was run separately for each industry as well as one model for the full data set for each of the Education level recodings – this was done in order to compare each industry to the larger sample. Specifics regarding the use of the IDB Analyzer are included in Appendix A.

PIAAC Measures. There were three cognitive skills defined and measured by PIAAC (OECD, 2012). *Literacy* was defined as "understanding, evaluating, using and engaging with written texts to participate in society, to achieve one's goals, and to develop one's knowledge and potential" (OECD, 2012, p. 20). *Numeracy* was defined as "the ability to access, use, interpret, and communicate mathematical information and ideas, in order to engage in and manage the mathematical demands of a range of situations in adult life" (OECD, 2012, p. 34). Lastly, *Problem-solving in Technology Rich Environments* was defined as "using digital technology, communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks" (OECD, 2012, p. 47). PIAAC focused on problem solving for personal, work, and civic purposes in a technology-rich environment. This definition is very specific to a technology-rich environment as compared to more general problem-solving skills. As a result it is important to keep this in mind while reviewing the results, implications, and limitations of this study.

Table 1

Education Variable Coding by Industry

Industry	Acronym used	Education Level					
		Less than High School	HS/HQ Equivalent	Post-HS Certificate or Similar	Associate Degree	Bachelor Degree	Graduate Degree
Some College Degrees							
Accommodation and food service	AFS	Same (reference)	Same	Same	College Degree		
Administrative and support service	AdSupp						
Construction	Construction						
More College Degrees							
Education	Education	No College Degree (reference)			College Degree		
Financial and Insurance	FI						
Human health and social work	HHS						
Public administration and defense; compulsory social security	PubAdmin						
Fewer College Degrees							
Wholesale and retail trade; repair of motor vehicles and motorcycles	WRT	Same (reference)	Same	Post-High school education			

Research Question 2

For Research Question 2, we examined cooperation/collaboration and information sharing and their relationships to various work activities for each of the eight industries. For each skill use at work measure, linear regression was run for COLL, INFO, EDUC and Gender in a full model for each industry. The variables were coded as they were for Research Question 1.

For Research Question 2 the four specified skills are reflected by four PIAAC-derived variables. All these are indexed variables which are derived from a series of questions on the PIAAC Survey. Each one is a measurement of the extent to which a person uses a particular type of skill at work. They are READWORK: to what extent one uses reading skills at work(e.g. reading directions, memos, forms, or books); WRITWORK: to what extent one uses writing skills at work (e.g. writing letters, memos, articles, or reports); NUMWORK: to what extent one uses numeracy skills at work (e.g. make or use calculations, prepare charts); and ICTWORK: to what extent one uses information and communication technology skills at work (e.g. use word processing, spread sheet programs, or an internet browser). For all four skills, the higher the indexed score the more frequently one uses the skill. The base model was represented with this linear regression model:

$$SKILLUSE = \beta_0 + \beta_1 COLL + \beta_2 INFO + \beta_3 EDUC + \beta_4 GENDER + Residual$$

The alpha level of .05 was used to determine significance for each variable's relationship to cooperation/collaboration and information sharing. In this model, SKILLUSE denoted the four Skills-use-at-work variables, β_0 designated the intercept value of the SKILLUSE variable, with the other variables being the same ones as in the model for Research Question 1.

Respondent Demographics

The complete U.S. PIAAC data set included 8,670 respondents (NCES, 2016), 3,243 of whom work in the eight selected industries and were considered for the present study. All respondents were between the ages of 16 and 74 years. Tables 2 and 3 present the number of participants in each industry by gender and education level. Across all selected industries, approximately 55% of respondents were women and the most common level of educational attainment was a high school diploma or equivalent, at about 41%. For this study only those who identified into one of the eight industries and answered the questions on cooperation/collaboration and information sharing, as well as gender and education level were included, which yielded a total of 2,601 complete respondent sets. Lastly, due to the requirement that survey respondents needed to take the PS-TRE assessment on a computer, the number of respondents for that model were lower than the other two.

Table 2

Gender by Industry for the Respondent Population for the Selected Industries

Industry	Male	Female	Total
Accommodation and food service	161	252	413
Administrative and support service	153	127	280
Construction	276	29	305
Education	143	316	459
Financial and insurance	88	120	208
Human health and social work	128	538	666
Public administration and defense; compulsory social security	174	119	293
Wholesale and retail trade; repair of motor vehicles and motorcycles	317	302	619
Total	1,440	1,803	3,243

Note: There were 2,601 complete respondent sets among the 3,243 individual respondents.

Table 3

Education Level by Industry for the Respondent Population for the Selected Industries

Industry	Less than High School	HS/HQ Equivalent	Post-HS Certificate or Similar	Associate Degree	Bachelor Degree	Graduate Degree	Total
Accommodation and food service	92	236	21	28	30	6	413
Administrative and support service	62	131	21	25	35	6	280
Construction	62	160	34	19	23	7	305
Education	10	84	14	25	138	187	458
Financial and insurance	3	63	17	25	74	26	208
Human health and social work	25	224	86	107	126	98	666
Public administration and defense; compulsory social security	2	91	29	30	86	55	293
Wholesale and retail trade; repair of motor vehicles and motorcycles	87	347	42	41	83	19	619
Total	343	1,336	264	300	595	404	3,242

Results

The purpose of the study was to examine relationships between cognitive skills, as measured by the PIAAC Survey, and the frequency that people engage in cooperation/collaboration at work as well as the extent to which they share work-related information from industry to industry. Some overarching results regarding cooperation/collaboration and information sharing by industry are included in Table 4 using the original five value PIAAC coding. The industry with highest measure of

cooperation/collaboration was AFS while the lowest was Education. With respect to sharing work-related information the highest score was in PubAdmin with the lowest in AdSupp. Results for the full models include a base score (the intercept) in each skill for each industry and the extent to which the skill is impacted by education level, gender, and the behaviors of collaborating at work and sharing work-related information.

Table 4

Means and Standard Deviations for Time Cooperating/Collaborating and Sharing of Work-related Information by Industry

	Time Cooperating/ Collaborating			Sharing Work-related Information		
Industry	*N*	*M*	*SD*	*N*	*M*	*SD*
All eight industries	2,989	3.81	1.36	3,242	4.18	1.31
Accommodation and food service	406	4.31	1.12	412	4.32	1.20
Administrative and support service	213	3.63	1.44	280	3.50	1.69
Construction	247	4.03	1.32	305	4.14	1.38
Education	441	3.27	1.36	459	4.07	1.21
Financial and insurance	195	3.35	1.29	208	4.37	1.05
Human health and social work	618	3.83	1.41	666	4.22	1.31
Public administration and defense; compulsory social security	290	3.84	1.24	293	4.59	0.88
Wholesale and retail trade; repair of motor vehicles and motorcycles	579	3.97	1.31	619	4.19	1.33

Research Question 1

The first research question was: what is the relationship between *cooperation/collaboration* and *information sharing* and *literacy, numeracy, and PS-TRE skills* across industry sectors, controlling for gender and education? The detailed results are presented in in Appendix B and the summary of the significant findings in Table 5. The results are organized according to the specific categorization of the Education level variable with "Less than High School" as the reference value. The model for four industries, Education, FI, HHS, and PubAdmin, had two education categories, which we named More College Degrees, and are

presented in the same way in Table R1.1 in Appendix B. The model for three industries, AFS, AdSupp, and Construction, had four categories for Education, which we named Some College Degrees, and are presented in detail in Table R1.2 in the Appendix B along with the results for all industries using the same values. The last industry, WRT, is presented alongside its model for all industries using three levels for education, which we named Fewer College Degrees, in Table R1.3 in Appendix B.

Research Question 2

The second question was: how does the relationship between *cooperation/collaboration* and *information sharing* and *adults' use of specified skills* differ by industry controlling for gender and education? The results are varied across industries and types of skill use. As with Research Question 1, the models are presented alongside the appropriate model for all industries in Tables R2.1, R2.2 and R2.3 in Appendix B. A summary of the significant findings pertaining to this research question is presented in Table 6.

Table 5

Summary of Significant Linear Regression Coefficients between PIAAC Skills and Cooperation/Collaboration and Information Sharing

		Literacy			Numeracy		PS-TRE		
		Time Cooperating/ Collaborating		Sharing Work-related information	Time Cooperating/ Collaborating[a]	Sharing Work-related information	Time Cooperating/ Collaborating		Sharing Work-related information
Industry	Acronym used	More than 1/2 the time	All the time	Once a week or more	All the time	Once a week or more	More than 1/2 the time	All the time	Once a week or more
All Industries[1]			-16.12*	13.19*	-19.15*	12.16*		-13.53*	9.65*
Accommodation and food service	AFS	23.42*					23.68*		
Administrative and support service	AdSupp		-25.91*		-28.05*				
Construction	Construction			22.41*		20.73*			
All Industries[2]			-18.53*	17.62*	-21.44*	16.42*		-13.88*	10.28*
Education	Education		-15.10*		-18.21*			-16.50*	
Financial and insurance	FI								
Human health and social work	HHS		-13.44*	27.20*	-16.90*	26.38*			
Public administration and defense; compulsory social security	PubAdmin				-17.44*			-14.57*	10.19*
All Industries[3]			-17.94*	13.96*	-21.23*	13.03*		-15.20*	10.18*
Wholesale and retail trade; repair of motor vehicles and motorcycles	WRT		-22.84*	23.34*	-27.22*	21.33*		-22.68*	16.47*

Note: * - $p < 0.05$. Estimates not shown were found not to be statistically significant.
Full results can be found in Tables R1.1, R1.2, and R1.3 in the Appendix B.
a – There were no significant coefficients for "More than 1/2 the time"
1 - All industries model run with the following education levels: HS or Equivalent; Post HS Cert or Similar; College Degree; with reference category Less than High School
2 - All industries model run with the following education levels: College Degree; with reference category No College Degree
3 - All industries model run with the following education levels: HS or Equivalent; Post HS education; with reference category Less than High School

Table 6

Summary of Significant Linear Regression Coefficients between Skills Use at Work and Cooperation/Collaboration and Information Sharing

		Reading Skill Use		Writing Skill Use	Numeracy Skill Use			ICT Skill Use		
		Time Cooperating/ Collaborating[a]	Sharing Work-related information	Sharing Work-related information	Time Cooperating/ Collaborating		Sharing Work-related information	Time Cooperating/ Collaborating		Sharing Work-related information
Industry	Acronym used	All the time	Once a week or more	Once a week or more	More than 1/2 of the time	All the time	Once a week or more	More than 1/2 of the time	All the time	Once a week or more
All Industries[1]			0.39*	0.44*			0.25*		-0.21*	0.38*
Accommodation and food service	AFS		0.37*							
Administrative and support service	AdSupp		0.38*							
Construction	Construction							0.81*	0.57*	
All Industries[2]			0.45*	0.46*			0.26*		-0.21*	0.39*
Education	Education					-0.10*				
Financial and insurance	FI									
Human health and social work	HHS	0.26*	0.50*	0.64*		0.52*				
Public administration and defense; compulsory social security	PubAdmin		0.39*							
All Industries[3]			0.40*	0.45*			0.26*		-0.24*	0.40*
Wholesale and retail trade; repair of motor vehicles and motorcycles	WRT	0.26*	0.35*	0.31*	0.29*		0.39*			

Note: * - $p < 0.05$.
Estimates not shown were found not to be statistically significant.
Full results can be found in Tables R2.1, R2.2, and R2.3 in the Appendix B.
a – There were no significant coefficients for "More than 1/2 the time"
1 - All industries model run with the following education levels: HS or Equivalent; Post HS Cert or Similar; College Degree; with reference category Less than High School
2 - All industries model run with the following education levels: College Degree; with reference category No College Degree
3 - All industries model run with the following education levels: HS or Equivalent; Post HS education; with reference category Less than High School

Discussion

Among the eight industries that were the focus of this study, PIAAC competencies were related to cooperation/collaboration at work and sharing of information in some of the eight industries. Skills use at work was related to cooperation/collaboration and information sharing in a small number of industries and in varying ways. The following sections present a detailed discussion of the two research questions, organized by the three industry education profiles in this study: More College Degrees, Some College Degrees, Fewer College Degrees.

PIAAC Competencies: Research Question 1

Research question 1 asked: What is the relationship between *cooperation/collaboration* and *information sharing* and *literacy, numeracy, and PS-TRE skills* across industry sectors, controlling for gender and education? Analysis revealed a negative correlation to all three PIAAC measures of competencies for those who cooperate all the time as compared to those who cooperate up to ½ time. There were no significant relationships between the PIAAC competencies and those who cooperated/collaborated up to ½ the time, however there were relationships for those who cooperated/collaborated more than ½ the time in AFS with respect to literacy and PS-TRE. Meanwhile, those that shared information once a week or more had a positive association with PIAAC competencies with varying degrees across industries and particular competencies.

Industry Education Profiles. The follow three sections present a discussion of the findings by industry education profiles.

More college degrees. The industries in this profile include Education, Finance and Insurance (FI), Human Health and Social Work (HHS), and Public Administration and Defense; Compulsory Social Security (PubAdmin). Time cooperating/collaborating is negatively related to

numeracy in each industry with people in Education, HHS, and PubAdmin who cooperate/collaborate all the time to have lower scores in numeracy (by 18 points, 17 points, and 17 points respectively) than those people who cooperate/collaborate up to ½ the time. Those who cooperate/collaborate all the time also had lower literacy scores in Education (15 points lower) and HHS (13 points lower), and as well as lower PS-TRE scores in Education (16 points lower) and PubAdmin (14 points lower). In addition, the sharing work-related information more than half the time compared to less is positively associated with both literacy and numeracy in HHS where those who share information once a week or more can expect a numeracy score 27 points higher than those who do not.

Some college degrees. The industries in this profile include Accommodation and Food Service (AFS), Administrative and Support Service (AdSupp), and Construction. Those in Construction who share work-related information once a week or more could expect scores 22 points and 21 points higher, in literacy and numeracy respectively, when compared with people who do not. Those in AFS can expect to see a higher literacy score (23 points) and higher PS-TRE scores (24 points) when cooperating more than half the time. Those in AdSupp have lower literacy and numeracy scores when they cooperate all the time.

Fewer college degrees. The one industry in this profile is Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles. Those in this industry who reported cooperating/collaborating all the time had lower scores in all three competencies, 23 points lower for literacy, 27 points lower for numeracy, and 23 points lower PSTRE compared to those who cooperate up to ½ time. The results also suggest that those who share work-related information once a week or more can expect higher scores in all three competencies (23 points higher in literacy, 21 points higher in numeracy, and 16 points higher in PS-TRE. These two

results also demonstrate that cooperation/collaboration are not only distinct activities but are different enough to have countering relationships to cognitive skills.

Summary for research question 1. The idea that one's literacy, numeracy and PSTRE skills are negatively related to frequent cooperation/collaboration differs from research that shows they are positively related (Kilgo, Sheets, & Pascarella, 2015; Ku, Teng & Akarasriworn, 2013; Latham, Julien, Gross, and Witte, 2016, Stennsma, 1996). One reason for this may be that the more people work in cooperative teams, the more they specialize in their particular skill set within the team. They take on the tasks they enjoy and do most effectively, thus avoid utilizing those skills in which they are weaker. Over a sufficient amount of time one would expect their ability to use those weaker skills would deteriorate. Another reason may be the reverse – that those people with lower PIAAC skills are more likely to cooperate/collaborate in their work than those with higher skills. In either case, these results provide a contrast to previous research.

Across all industries (for all educational profiles), those who share work-related information once a week or more can expect to have higher literacy, numeracy, and PS-TRE scores and vice-versa. One possible explanation for this finding may be that jobs in which the job-holder is required to share information also requires literacy, numeracy, and PS-TRE competencies, resulting in higher scores. Alternatively, it may be that if a job-holder is frequently interacting with and sharing information, or information is a central commodity of the job, then the job-holder is continuously using, and therefore maintaining or updating, PIAAC-related competencies.

Yet unknown is the direction of the relationship between PIAAC competencies and cooperation/collaboration and information sharing, leaving the following open questions: Do high levels of cooperation/collaboration and information sharing lead to a changed level in

PIAAC competencies? Or, do job-holders' levels of PIAAC competency lead them to jobs that require correspondingly more or less cooperation/collaboration and information sharing? What is the relationship between cooperation/collaboration and information sharing?

Emphasis, or perhaps over-emphasis, on cooperation/collaboration as opposed to a more transactional approach of sharing work-related information has some potential to diminish individual performance on PIAAC cognitive competencies. These results have implications for the workplace. For example, employers may wish to consider opportunities to encourage sharing work-related information to balance expectations of cooperation/collaboration. Such encouragement may mean giving job-holders information and having them perform job tasks alone rather than creating highly cooperative environments in which job-holders rely on one another.

Skills Use at Work: Research Question 2

Research question 2 asked: How does the relationship between cooperation/collaboration and information sharing and *adults' use of specified skills* differ by industry, controlling for gender and education? The four specific skills were reading, writing, numeracy, and information and communication technology (ICT). The results from the second research question, which focused on how often people use various skills, showed that when a significant relationship did exist, cooperation/collaboration at work and sharing work-related information were positively related to skills with the exception the relationship between cooperation/collaboration and ICT Skill use. Sharing work-related information did have a stronger relationship that cooperation/collaboration, although the extent of the relationship varied by industry. Writing Skill use was shown to not be significantly related to cooperation/collaboration. Sharing work-related information was positively related to the use of specified skills across industries while

collaborating at work was only related to skills use in four industries – Construction, Education, HHS, and WRT. As with the PIAAC competencies, education level was positively correlated to many of the measures of skills use.

Industry Education Profiles. The follow three sections present a discussion of the findings by industry education profiles.

More college degrees. From the four industries corresponding to this educational profile, HHS showed a positive relationship between reading, writing and numeracy and sharing work-related information and a positive relationship between reading and levels of cooperation/collaboration. In PubAdmin, reading use increased with sharing work related information once a week or more. Those in Education had a negative relationship between numeracy skill use and cooperating all the time.

Some college degrees. In this industry educational profile, there are four significant relationships. Reading skill was positively related to sharing work information once a week or more in AFS and AdSupp. Construction saw a positive correlation in ICT skill use for those who collaborated more than half the time and all the time.

Fewer college degrees. This profile includes only the WRT industry. Sharing work related information once a week or more was positively correlated to reading, writing and numeracy skill use on the job. Cooperating all the time was also correlated with reading skill use, while cooperating more than half the time was positively correlated with numeracy skill use.

Summary for research question 2. For the four skills analyzed, reading skill use is positively correlated with the sharing of work related information in five of eight industries. Writing skill use was strongly correlated with sharing work related information once a week or more in HHS and WRT. Numeracy skill use was negatively related to cooperation/collaboration

in Education and positively related to collaboration in HHS and WRT. Finally, ICT was positively correlated with collaboration time in Construction only. This finding is interesting for it suggests that, when compared to all other industries in this study, workers in the Construction industry are more likely to collaborate via ICT than workers in other industries. One explanation for this finding is that coordination of the work of many trades across shifts and projects sites and the use of complex project management system leads the industry towards a heavy reliance on ITC systems to manage the communications flow within the industry. For this second question, the results regarding sharing work related information seem to align with the findings from the first question because they are both positively related to literacy.

Observations Across Research Questions

The negative relationships found in research question one between cooperation/collaboration and PIAAC competencies challenged empirically-based and widely-held conceptions related to the benefits of cooperation/collaboration for individual skill acquisition and maintenance (Kilgo, Sheets, & Pascarella, 2015; Ku, Tseng, & Akarasriworn, 2013; Latham, Julien, Gross, & Witte, 2016; Steensma, 1996). This finding is contradicted in part by the findings in research question two which shows that cooperation/collaboration is not related to a job-holder's use of various skills associated with the PIAAC competencies, such as reading, writing, numeracy, and ICT at work. Therefore, the relationship between cooperation/collaboration and the learning or maintenance of PIAAC competencies is inconclusive.

Information sharing, on the other hand was positively related to the three PIAAC competencies (RQ1) as well as the use of reading skills at work (RQ2) in five of the eight industries. These positive correlations between PIAAC competencies and information sharing,

and information sharing and reading skill use on the job may be interpreted in a couple of ways. For example, reading skill use and PIAAC competencies could be moderated by information sharing, in other words people who consume information (i.e. read) may be more likely to be sources of information to others at work (i.e. share information). On the other hand, people who share information on the job may simply be required to often read on the job, leading to an improved performance on PIAAC competencies.

The positive relationship between information sharing and PIAAC competencies (RQ1), information sharing and reading skills at work (RQ2) but the inconclusive relationship between cooperation/collaboration suggest that there are inherently different learning requirements and opportunities in information sharing versus cooperation/collaboration. For example, cooperation/collaboration may encourage a divide and conquer approach that allows individuals to stay within an existing specialization rather than learn, creating depth of skill but not breadth. Additionally, the communication burden in information sharing versus cooperation/collaboration may require different utilization of PIAAC competencies and related skills at work. Lastly, it is possible that these two measures are capturing or masking a source of variation associated with skills and skills use. Certainly, these results generate more questions than they answer.

Implications for policy

This study's results have implications for policy at the international, national and organizational levels. Results suggest human interactions in a work environment, cooperation/collaboration and sharing work-related information, are related to the PIAAC competencies. These findings suggest the need for future research on the links between so-called soft skills and labor market outcomes in the new economy, as well as their role in the formation and maintenance of the cognitive competencies measured by PIAAC. Internationally, OECD

recognized the importance of these skills by including questions related to the use of soft skills in the background questionnaire of the PIAAC survey. In the future, OECD may work to develop a robust measure of soft skills to support their assessment in future cycles of PIAAC (Martin, 2018). Such a measure would enable researchers to conduct deeper analysis on the role of soft skills in adult workplace learning and labor market success (Martin, 2018).

For national policy, this information could impact the design and delivery of workforce development programs and adult basic education programs, both of which are key to preparing individuals to contribute in work environments. In particular, we suggest creating workforce development opportunities that specifically aim leverage individuals' knowledge sharing skills in addition to abilities to collaborate effectively. Organizational policy makers should consider the ways in which employees' PIAAC competencies and corresponding ability to successfully complete work will support achieving an organization's goals. More skillful employees are more likely to be adaptable to changing work environments and organizational pressures, making them better contributors over time and supporting organizational survival in changing economic conditions. As such, designing tasks and responsibilities in which people share work-related information rather than collaborating may build stronger employee skills with respect to PIAAC competencies that can yield organizational benefits. That said, the contradictory findings in this study suggest that more research on the role of cooperation/collaboration and information sharing in cognitive skill development and maintenance is imperative.

Limitations of the study

Limitations of the study include the possibility that by limiting our analysis to the complete cases for each of our models, the results may not be as generalizable. A limitation specific to the PS-TRE model for RQ1 is that the population was different than those for LIT and

NUM. This was due to the PS-TRE responses that were only those from people who were able to complete the assessment on a computer – those who took a paper assessment for PS-TRE did not get a score. Additionally, regarding participant employment, the industry sectors and job types are classified according to broad, internationally relevant categories, creating limitations for interpreting the data and results by sector.

A further limitation of the analysis is the vagaries of language coupled with inability to draw casual direction. For example, the results do not indicate whether people with high skills simply cooperate/collaborate less or people who cooperate/collaborate more do so because they have low skills. There's also the limitation that the collaboration/cooperation and information-sharing measures are confounded with other variables not accounted for in the model. Lastly, regardless of the specificity with which cooperation, collaboration, and information sharing and other such terms are defined, their definitions vary from person to person thus introducing a source of variance that cannot be eliminated from surveys such as the PIAAC Background Questionnaire.

Plans for future research

Future investigations by this research team will emphasize learning at work. Building from the present research question, we will expand to explore other qualities of participants' work context that may influence their learning and subsequent performance on the three PIAAC variables of literacy, numeracy, and problem-solving in technology-rich environments. For example, relevant variables and work qualities include autonomy in work tasks, variety of work tasks, task significance, job complexity, and feedback on work performance. This study will be a key starting point to analyze additional future connections between work and job functions and activities, learning at work, and cognitive skills.

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Appendix A

IDB Analyzer specifics for Research Question 1

Listwise deletion option for missing data, two decimals

Grouping variables: US, Industry classification (ISIC1C)

Independent variables (Categorical): F_Q01b (Cooperating with others); F_Q02a (Sharing work-related info)

Control variables (Categorical) Degree (derived from Educ Lvl) with various reference groups – see main for more details, and Gender_R with males as the reference group.

Dependent variable (Continuous): PIAAC Skill Plausible Values: LIT, NUM, PSTRE, one skill at a time for each analysis.

IDB Analyzer specifics for Research Question 2

Listwise deletion option for missing data, two decimals

Grouping variables: US, Industry classification (ISIC1C)

Independent variables (Categorical): F_Q01b (Cooperating with others); F_Q02a (Sharing work-related info)

Control variables (Categorical) Degree (derived from Educ Lvl) with various reference groups – see main for more details, and Gender_R with males as the reference group.

Dependent variable (SKILLUSE): PIAAC-derived non-plausible values with reference variables: READWORK (G_Q01a, G_Q01b, G_Q01c, G_Q01d, G_Q01e, G_Q01f, G_Q01g, G_Q01h), NUMWORK (G_Q03b, G_Q03c, G_Q03d,

G_Q03f, G_Q03g, G_Q03h), WRITWORK (G_Q02a, G_Q02b, G_Q02c, G_Q02d), and ICTWORK (G_Q05a, G_Q05c, G_Q05d, G_Q05e, G_Q05f, G_Q05h).

Appendix B

Table R1.1

Means and Linear Regression Coefficients of PIAAC Measures by Industry with More College Degrees

Industry Sector	LIT			NUM			PSTRE		
	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*
All Industries									
M	254.73*	3.26	78.07	248.51*	3.07	80.90	263.83*	3.15	83.78
Time Cooperating/Collaborating									
More than 1/2 time	-1.59	2.48	-0.64	0.79	2.42	0.33	0.55	2.83	0.19
All of the time	-18.53*	2.62	-7.07	-21.44*	2.80	-7.67	-13.88*	2.44	-5.69
Sharing Work-related Information									
Once a week or more	17.62*	2.57	6.86	16.42*	2.60	6.32	10.28*	2.52	4.09
Education level									
College Degree	36.67*	2.04	17.99	41.41*	1.99	20.82	23.79*	1.96	12.14
Gender									
Female	0.57	1.40	0.41	-14.03*	1.44	-9.76	-3.52*	1.70	-2.07
R^2	0.21			0.23			0.12		
Education									
M	276.92*	7.37	37.55	268.28*	7.85	34.18	277.26*	9.94	27.88
Time Cooperating/Collaborating									
More than 1/2 time	-6.49	7.37	-0.88	-3.13	7.64	-0.41	-4.37	8.41	-0.52
All of the time	-15.10*	4.88	-3.10	-18.21*	6.31	-2.89	-16.50*	5.15	-3.20
Sharing Work-related Information									
Once a week or more	3.98	4.70	0.85	4.91	5.44	0.90	3.21	5.08	0.63
Education level									
College Degree	28.40*	7.17	3.96	30.90*	7.37	4.19	15.95	8.58	1.86
Gender									
Female	0.34	5.58	0.06	-12.17*	5.80	-2.10	-0.46	5.14	-0.09
R^2	0.15						0.07		

Note: * indicates significance at the .05 level.
Note: ! indicates the results should be interpreted with caution due to small sample size (between 30 and 61 cases).
Note: ‡ indicates reporting standards not met (less than 30 cases).

Table R1.1 *(continued)*

Industry Sector	LIT			NUM			PSTRE		
	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*
Financial and insurance activities									
M	272.56*	14.91	18.29	249.08*	16.41	15.18	272.60*	13.33	20.46
Time Cooperating/Collaborating									
More than 1/2 time	-9.26	9.66	-0.96	-1.52	10.78	-0.14	1.70	8.00	0.21
All of the time	-19.65	10.40	-1.89	-13.78	11.21	-1.23	-6.52	9.38	-0.70
Sharing Work-related Information									
Once a week or more	9.63	10.93	0.88	16.66	11.28	1.48	5.43	9.72	0.56
Education level									
College Degree	28.74*	9.03	3.18	43.70*	9.88	4.42	22.58*	9.04	2.50
Gender									
Female	4.94	7.46	0.66	-11.14	7.59	-1.47	-6.63	6.83	-1.00
R^2	0.16			0.28			0.11		
Human health and social work activities									
M	247.39*	8.89	27.82	236.08*	8.26	28.57	256.22	9.53	26.90
Time Cooperating/Collaborating									
More than 1/2 time	-3.21	5.73	-0.56	-5.41	5.91	-0.91	2.98	6.92	0.43
All of the time	-13.44*	5.04	-2.67	-16.90*	5.44	-3.11	-8.59	4.72	-1.82
Sharing Work-related Information									
Once a week or more	27.20*	7.91	3.44	26.38*	7.99	3.30	16.41	8.91	1.84
Education level									
College Degree	36.50*	4.08	8.95	40.79*	5.13	7.95	24.37*	4.26	5.73
Gender									
Female	2.48	1.40	1.77	-20.10*	6.54	-3.07	-12.86*	6.25	-2.06
R^2	0.23			0.25			0.14		
Public administration and defence; compulsory social security									
M	264.15	12.83	20.58	262.60	13.04	20.14	263.43	3.17	83.19
Time Cooperating/Collaborating									
More than 1/2 time	-0.84	6.90	-0.12	2.37	9.21	0.26	0.45	3.00	0.15
All of the time	-12.23	6.90	-1.77	-17.44*	7.95	-2.19	-14.57*	2.48	-5.87
Sharing Work-related Information									
Once a week or more	19.98	11.79	1.69	13.05	12.17	1.07	10.19*	2.57	3.96
Education level									
College Degree	28.71*	6.75	4.25	32.63	7.51	4.34	23.64*	2.05	11.54
Gender									
Female	-4.19	5.49	-0.76	-20.45*	6.42	-3.19	-11.86	7.75	-1.53
R^2	0.17			0.22			0.11		

Note: * indicates significance at the .05 level.
Note: ! indicates the results should be interpreted with caution due to small sample size (between 30 and 61 cases).
Note: ‡ indicates reporting standards not met (less than 30 cases).

Table R1.2

Means and Linear Regression Coefficients of PIAAC Measures by Industry with Some College Degrees

Industry Sector	LIT			NUM			PSTRE		
	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*
All Industries									
M	225.68*	4.06	55.64	220.81*	3.65	60.50	255.35*	4.68	54.61
Time Cooperating/Collaborating									
More than 1/2 time	-1.07	2.35	-0.46	1.26	2.30	0.55	0.62	2.82	0.22
All of the time	-16.12*	2.43	-6.63	-19.15*	2.62	-7.31	-13.53*	2.40	-5.64
Sharing Work-related Information									
Once a week or more	13.19*	2.48	5.31	12.16*	2.46	4.95	9.65*	2.52	3.84
Education level									
HS or Equivalent	37.30*	3.10	12.03	35.24*	2.78	12.69	9.25*	3.70	2.50
Post HS Cert or Similar	43.54*	3.61	12.07	43.31*	3.84	11.29	12.29*	4.62	2.66
College Degree	69.32*	3.60	19.24	72.60*	3.39	21.44	32.53*	3.98	8.18
Gender									
Female	-0.66	1.31	-0.50	-15.26*	1.33	-11.49	-3.79*	1.71	-2.23
R^2	0.26			0.27			0.12		
Accommodation and food service activities									
M	207.75*	12.15	17.10	197.43*	12.07	16.36	242.88*	12.93	18.78
Time Cooperating/Collaborating									
More than 1/2 time	23.42*	10.97	2.13	23.80	12.47	1.91	23.68*	10.82	2.19
All of the time	11.29	9.53	1.18	9.57	9.85	0.97	13.11	10.70	1.22
Sharing Work-related Information									
Once a week or more	-0.51	7.11	-0.07	0.71	7.12	0.10	-6.07	9.12	-0.67
Education level									
HS or Equivalent	39.90*	7.40	5.39	38.76*	7.93	4.88	19.03*	7.81	2.44
Post HS Cert or Similar	45.24‡	12.13	3.73	47.31‡	12.15	3.89	21.12	12.54	1.68
College Degree	65.15*	9.91	6.58	67.58*	10.56	6.40	31.81!	10.83	2.94
Gender									
Female	4.48	5.94	0.75	-4.90	6.10	-0.80	1.45	5.80	0.25
R^2	0.17			0.17			0.07		

Note: * indicates significance at the .05 level.
Note: ! indicates the results should be interpreted with caution due to small sample size (between 30 and 61 cases).
Note: ‡ indicates reporting standards not met (less than 30 cases).

Table R1.2 *(continued)*

Industry Sector	LIT			NUM			PSTRE		
	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*
Administrative and support service activities									
M	222.53*	14.54	15.30	217.19*	15.03	14.45	264.94*	14.82	17.87
Time Cooperating/Collaborating									
More than 1/2 time	-7.30	9.79	-0.75	-9.95	11.15	-0.89	-7.57	10.74	-0.70
All of the time	-25.91*	9.20	-2.82	-28.05*	9.87	-2.84	-18.66	9.36	-1.99
Sharing Work-related Information									
Once a week or more	13.45	10.89	1.23	8.20	11.37	0.72	6.19	11.45	0.54
Education level									
HS or Equivalent	31.95*	11.75	2.72	28.93*	12.32	2.35	-7.40	13.24	-0.56
Post HS Cert or Similar	25.72	15.79	1.63	28.29	16.75	1.69	-25.37	17.88	-1.42
College Degree	61.21*	13.31	4.60	70.10*	14.85	4.72	10.56	15.07	0.70
Gender									
Female	11.28	7.52	1.50	0.34	8.52	0.04	14.99	8.81	1.70
R^2	0.29			0.31			0.18		
Construction									
M	215.92*	15.43	13.99	210.00*	13.92	15.08	235.12*	15.23	15.44
Time Cooperating/Collaborating									
More than 1/2 time	-0.86	12.05	-0.07	7.97	11.25	0.71	4.53	13.79	0.33
All of the time	-16.60	12.43	-1.34	-19.17	11.01	-1.74	-18.65	10.62	-1.76
Sharing Work-related Information									
Once a week or more	22.41*	10.19	2.20	20.73*	9.83	2.11	25.88	14.79	1.75
Education level									
HS or Equivalent	31.67*	9.96	3.18	32.36*	10.32	3.14	1.19	8.39	0.14
Post HS Cert or Similar	44.14!	14.83	2.98	62.51!	17.31	3.61	21.93‡	10.83	2.03
College Degree	48.50!	13.49	3.59	57.54!	13.07	4.40	16.30	12.30	1.33
Gender									
Female	9.27	8.29	1.12	-11.00	9.51	-1.16	10.02	12.05	0.83
R^2	0.18			0.23			0.13		

Note: * indicates significance at the .05 level.

Note: ! indicates the results should be interpreted with caution due to small sample size (between 30 and 61 cases).

Note: ‡ indicates reporting standards not met (less than 30 cases).

Table R1.3

Means and Linear Regression Coefficients of PIAAC Measures with Fewer College Degrees

Industry Sector	LIT			NUM			PSTRE		
	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*
All Industries									
M	226.31*	4.06	55.73	221.53*	3.68	60.26	256.32*	4.70	54.50
Time Cooperating/Collaborating									
More than 1/2 time	-1.34	2.32	-0.58	0.96	2.30	0.42	0.22	2.84	0.08
All of the time	-17.94*	2.31	-7.76	-21.23*	2.52	-8.44	-15.20*	2.31	-6.59
Sharing Work-related Information									
Once a week or more	13.96*	2.56	5.46	13.03*	2.52	5.17	10.18*	2.57	3.96
Education level									
HS or Equivalent	36.99*	3.11	11.90	34.89*	2.78	12.56	9.04*	3.70	2.44
Post HS Cert or Higher	64.02	3.47	18.47	66.58*	3.25	20.51	28.52*	3.95	7.22
Gender									
Female	-0.68	1.36	-0.50	-15.28*	1.40	-10.91	-3.83*	1.76	-2.18
R^2	0.24			0.25			0.11		
Wholesale and retail trade; repair of motor vehicles and motorcycles									
M	217.74*	8.61	25.29	217.19*	8.82	24.63	252.70*	8.91	28.35
Time Cooperating/Collaborating									
More than 1/2 time	-3.56	6.19	-0.58	-1.96	6.51	-0.30	-2.26	7.04	-0.32
All of the time	-22.84*	5.26	-4.34	-27.22*	5.37	-5.07	-22.68*	5.51	-4.11
Sharing Work-related Information									
Once a week or more	23.34*	5.77	4.05	21.33*	6.67	3.20	16.47*	7.20	2.29
Education level									
HS or Equivalent	40.62*	8.02	5.07	35.88*	7.18	5.00	7.59	7.13	1.06
Post HS Cert or Higher	56.88*	8.11	6.97	54.84*	8.15	6.73	23.11*	8.66	2.67
Gender									
Female	3.63	4.47	0.81	-9.27	4.72	-1.96	1.37	4.61	0.30
R^2	0.27			0.26			0.13		

Note: * indicates significance at the .05 level.
Note: ! indicates the results should be interpreted with caution due to small sample size (between 30 and 61 cases).
Note: ‡ indicates reporting standards not met (less than 30 cases).

Table R2.1

Means and Regression Coefficients of Indexed Skill Use at Work by Industry with More College Degrees

Industry Sector	Reading Skills			Writing Skills			Numeracy Skills			ICT Skills		
	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*
All Industries												
M	1.60*	0.05	31.63	1.63*	0.06	29.57	1.98*	0.06	34.49	1.61*	0.07	23.21
Time Cooperating/Collaborating												
More than 1/2 time	0.02	0.05	0.34	0.00	0.05	0.02	0.05	0.04	1.22	0.06	0.05	1.20
All of the time	-0.04	0.04	-1.20	-0.01	0.04	-0.27	-0.02	0.04	-0.43	-0.21*	0.05	-4.18
Sharing Work-related Information												
Once a week or more	0.45*	0.05	9.86	0.46*	0.05	10.05	0.26*	0.05	4.86	0.39*	0.05	7.42
Education level												
College Degree	0.65*	0.03	23.58	0.49*	0.03	16.10	0.33*	0.04	8.75	0.57*	0.04	13.28
Gender												
Female	-0.10*	0.03	-3.82	-0.05	0.03	-1.60	-0.24*	0.04	-6.23	-0.12*	0.04	-2.92
R^2	0.14			0.08			0.05			0.10		
Education												
M	1.88*	0.17	10.81	1.76*	0.18	9.89	1.80*	0.23	7.71	1.60*	0.24	6.62
Time Cooperating/Collaborating												
More than 1/2 time	0.07	0.20	0.35	0.18	0.12	1.51	-0.04	0.14	-0.66	0.16	0.13	1.21
All of the time	0.04	0.11	0.32	0.20	0.14	1.42	-0.10*	0.15	2.01	-0.08	0.13	-0.64
Sharing Work-related Information												
Once a week or more	0.25	0.11	2.33	0.22	0.12	1.84	0.34	0.17	2.01	0.23	0.14	1.64
Education level												
College Degree	0.88*	0.15	5.97	0.62*	0.14	4.32	0.26	0.17	1.51	0.57*	0.15	3.78
Gender												
Female	-0.15	0.11	-1.37	-0.04	0.10	-0.35	-0.12	0.10	-1.17	-0.15	0.11	-1.33
R^2	0.18			0.08			0.04			0.10		

Note: * indicates significance at the .05 level.

Table R2.1 *(continued)*

Industry Sector	Reading Skills			Writing Skills			Numeracy Skills			ICT Skills		
	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*
Financial and insurance activities												
M	2.56*	0.21	12.30	2.37*	0.18	12.97	2.62*	0.23	11.48	2.48*	0.26	9.42
Time Cooperating/Collaborating												
More than 1/2 time	0.12	0.21	0.58	0.03	0.17	0.18	0.11	0.12	0.88	0.08	0.20	0.37
All of the time	-0.04	0.16	-0.24	0.11	0.16	0.68	0.16	0.16	1.02	-0.21	0.25	-0.83
Sharing Work-related Information												
Once a week or more	0.18	0.14	1.30	0.07	0.16	0.41	-0.02	0.24	-0.09	0.36	0.22	1.62
Education level												
College Degree	-0.12	0.15	-0.80	0.01	0.12	0.11	0.18	0.14	1.31	0.15	0.19	0.78
Gender												
Female	-0.21	0.13	-1.63	0.05	0.11	0.44	-0.28*	0.12	-2.41	0.00	0.15	0.00
R^2	0.03			0.01			0.04			0.03		
Human health and social work activities												
M	1.47*	0.12	12.15	1.96*	0.14	13.94	1.39*	0.16	8.52	1.59*	0.16	9.85
Time Cooperating/Collaborating												
More than 1/2 time	0.13	0.10	1.21	-0.22	0.13	-1.72	0.06	0.17	0.38	0.02	0.15	0.15
All of the time	0.26*	0.07	3.56	0.08	0.09	0.85	0.02	0.12	0.15	-0.03	0.10	-0.26
Sharing Work-related Information												
Once a week or more	0.50*	0.09	5.78	0.64*	0.13	4.73	0.52*	0.12	4.41	0.22	0.14	1.55
Education level												
College Degree	0.47*	0.06	8.30	0.30*	0.09	3.46	*0.28	0.08	3.50	0.24*	0.09	2.62
Gender												
Female	-0.01	0.09	-0.06	-0.33*	0.12	-2.81	-0.10	0.11	-0.87	-0.21	0.11	-1.91
R^2	0.18			0.11			0.07			0.04		

Note: * indicates significance at the .05 level.

Table R2.1 *(continued)*

Industry Sector	Reading Skills			Writing Skills			Numeracy Skills			ICT Skills		
	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*
Public administration and defence; compulsory social security												
M	2.16*	0.17	13.00	2.49	0.27	9.09	2.29*	0.36	6.45	1.96*	0.28	6.90
Time Cooperating/Collaborating												
More than 1/2 time	0.04	0.13	0.33	0.23	0.15	1.55	0.15	0.25	0.59	0.20	0.16	1.23
All of the time	-0.05	0.13	-0.36	0.10	0.18	0.56	-0.18	0.24	-0.75	-0.11	0.15	-0.71
Sharing Work-related Information												
Once a week or more	0.39*	0.18	2.21	0.07	0.28	0.24	-0.40	0.33	-1.21	0.10	0.28	0.37
Education level												
College Degree	0.34*	0.11	3.02	0.16	0.14	1.08	0.41*	0.17	2.41	0.34*	0.16	2.15
Gender												
Female	-0.34*	11.00	-3.20	-0.17	0.12	-1.50	-0.09	0.14	-0.64	0.03	0.14	0.21
R^2	0.14			0.08			0.06			0.10		

Note: * indicates significance at the .05 level.

Table R2.2

Means and Regression Coefficients of Indexed Skill Use at Work by Industry with Some College Degrees

Industry Sector	Reading Skills			Writing Skills			Numeracy Skills			ICT Skills		
	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*
All Industries												
M	1.06*	0.06	18.47	1.19*	0.10	12.42	1.84*	0.07	26.46	1.20*	0.11	10.55
Time Cooperating/Collaborating												
More than 1/2 time	0.02	0.05	0.52	0.01	0.05	0.15	0.05	0.04	1.29	0.06	0.05	1.25
All of the time	0.00	0.03	-0.05	0.01	0.04	0.19	-0.01	0.04	-0.25	-0.21*	0.05	-3.99
Sharing Work-related Information												
Once a week or more	0.39*	0.05	8.55	0.44*	0.05	9.70	0.25*	0.05	4.70	0.38*	0.05	7.05
Education level												
HS or Equivalent	0.64*		11.98	0.48*	0.08	5.63	0.15*	0.06	2.68	0.42*	0.09	4.45
Post HS Cert or Similar	0.90*		9.79	0.65*	0.10	6.26	0.24*	0.07	3.50	0.53*	0.14	3.93
College Degree	1.24*		26.41	0.95*	0.09	10.82	0.48*	0.06	8.24	0.98*	0.11	9.14
Gender												
Female	-0.12*		-4.83	-0.06	0.03	-1.78	-0.25*	0.04	-6.27	-0.13*	0.04	-3.04
R^2	0.18			0.09			0.05			0.11		
Accommodation and food service activities												
M	0.64*	0.19	3.28	1.32*	0.34	3.82	2.04*	0.27	7.47	1.32*	0.64	2.07
Time Cooperating/Collaborating												
More than 1/2 time	0.03	0.18	0.17	-0.52	0.29	-1.75	0.14	0.21	0.67	0.29	0.31	0.94
All of the time	0.27	0.17	1.57	-0.17	0.23	-0.75	0.32	0.16	1.94	0.38	0.25	1.53
Sharing Work-related Information												
Once a week or more	0.37*	0.16	2.36	0.58	0.31	1.85	-0.05	0.24	-0.22	-0.24	0.68	-0.36
Education level												
HS or Equivalent	0.42*	0.09	4.46	0.06	0.20	0.28	-0.06	0.14	-0.45	0.14	0.26	0.52
Post HS Cert or Similar	0.39	0.32	1.25	0.26	0.62	0.41	0.17	0.24	0.72	0.04	0.36	0.11
College Degree	1.06*	0.24	4.34	0.83*	0.24	3.43	0.39	0.24	1.66	0.80*	0.30	2.63
Gender												
Female	-0.16	0.12	-1.30	-0.29	0.21	-1.36	-0.24	0.15	-1.56	-0.41	0.22	-1.84
R^2	0.17			0.16			0.06			0.16		

Note: * indicates significance at the .05 level.

Table R2.2 *(continued)*

Industry Sector	Reading Skills			Writing Skills			Numeracy Skills			ICT Skills		
	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*
Administrative and support service activities												
M	0.58*	0.21	2.85	1.12*	0.36	3.09	1.57*	0.23	6.69	0.85*	0.31	2.73
Time Cooperating/Collaborating												
More than 1/2 time	-0.41	0.25	-1.66	-0.46	0.28	-1.62	-0.12	0.22	-0.54	0.51	0.36	1.41
All of the time	0.00	0.17	-0.01	0.26	0.22	1.21	-0.04	0.20	-0.21	0.50	0.28	1.80
Sharing Work-related Information												
Once a week or more	0.38*	0.16	2.34	0.24	0.20	1.22	0.27	0.21	1.27	0.17	0.33	0.51
Education level												
HS or Equivalent	1.00*	0.28	3.61	0.93*	0.39	2.37	0.34	0.22	1.54	0.64	0.35	1.85
Post HS Cert or Similar	1.52‡	0.71	2.15	0.50	0.48	1.04	0.98	0.51	1.90	0.95	0.59	1.62
College Degree	1.32*	0.32	4.19	1.27*	0.39	3.27	0.93*	0.26	3.59	1.31*	0.35	3.73
Gender												
Female	-0.05	0.17	-0.31	-0.05	0.03	-1.46	-0.32	0.18	-1.75	-0.09	0.32	-0.28
R^2	0.20			0.16			0.11			0.10		
Construction												
M	1.04*	0.30	3.48	1.36*	0.37	3.66	1.75*	0.20	8.75	0.61	0.56	1.08
Time Cooperating/Collaborating												
More than 1/2 time	0.09	0.22	0.41	0.45	0.26	1.73	0.29	0.19	1.53	0.81*	0.36	2.24
All of the time	0.03	0.18	0.17	0.03	0.19	0.13	0.23	0.19	1.25	0.57*	0.27	2.16
Sharing Work-related Information												
Once a week or more	0.19	0.20	0.96	0.35	0.29	1.21	0.27	0.19	1.42	0.10	0.38	0.26
Education level												
HS or Equivalent	0.84*	0.28	3.06	0.22	0.30	0.76	0.16	0.17	0.95	0.76	0.42	1.79
Post HS Cert or Similar	0.94!	0.26	3.61	0.04	0.39	0.11	0.38	0.22	1.42	0.37	0.46	0.81
College Degree	1.25!	0.32	3.61	0.79*	0.36	2.22	0.90*	0.22	4.04	1.34*	0.47	2.87
Gender												
Female	-0.31	0.25	-1.20	-0.40	0.28	-1.39	-0.03	0.04	-0.70	-0.22*	0.05	-4.23
R^2	0.12			0.12			0.13			0.18		

Note: * indicates significance at the .05 level.

Table R2.3

Means and Regression Coefficients of Indexed Skill Use at Work with Fewer College Degrees

Industry Sector	Reading Skills			Writing Skills			Numeracy Skills			ICT Skills		
	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*	b_i	*SE*	*t*
All Industries												
M	1.07*	0.06	18.17	1.19*	0.10	12.51	1.84*	0.07	26.66	1.21*	0.12	10.54
Time Cooperating/Collaborating												
More than 1/2 time	0.02	0.05	0.42	0.01	0.05	0.14	0.05	0.04	1.23	0.06	0.05	1.17
All of the time	-0.03	0.04	-0.69	-0.01	0.04	-0.27	-0.03	0.04	-0.69	-0.24*	0.05	-4.75
Sharing Work-related Information												
Once a week or more	0.40*	0.05	8.60	0.45*	0.05	9.91	0.26*	0.05	4.86	0.40*	0.06	6.93
Education level												
HS or Equivalent	0.64*	0.05	11.94	0.47*	0.08	5.60	0.15*	0.06	2.64	0.41*	0.09	4.37
Post HS Cert or Higher	1.17*	0.05	23.15	0.89*	0.09	10.30	0.43*	0.05	7.90	0.91*	0.11	8.41
Gender												
Female	-0.12*	0.03	-4.64	-0.06	0.03	-1.76	-0.25*	0.04	-6.17	-0.12*	0.04	-3.00
R^2	0.17			0.09			0.05			0.09		
Wholesale and retail trade; repair of motor vehicles and motorcycles												
M	1.16*	0.14	8.13	0.95*	0.23	4.07	1.56*	0.18	8.52	1.17*	0.28	4.13
Time Cooperating/Collaborating												
More than 1/2 time	0.02	0.18	0.13	0.27	0.17	1.55	0.29*	0.13	2.24	-0.03	0.17	-0.16
All of the time	0.26*	0.11	2.28	0.17	0.14	1.19	0.16	0.11	1.45	-0.20	0.13	-1.54
Sharing Work-related Information												
Once a week or more	0.35*	0.10	3.64	0.31*	0.13	2.31	0.39*	0.11	3.60	0.27	0.19	1.43
Education level												
HS or Equivalent	0.52*	0.13	3.94	0.50*	0.21	2.37	0.23	0.13	1.82	0.24	0.22	1.11
Post HS Cert or Higher	0.94*	0.12	7.89	0.79*	0.24	3.33	0.64*	0.14	4.45	0.82*	0.24	3.40
Gender												
Female	-0.25*	0.09	-2.89	0.00	0.11	0.02	-0.07	0.11	-0.64	0.02	0.12	0.19
R^2	0.11			0.05			0.08			0.09		

Note: * indicates significance at the .05 level.