Commissioned Paper
January 2022

Assessed Skills and Skill Use of Adults with Learning Disabilities in PIAAC

Author:
Margaret Becker Patterson

Suggested Citation: Patterson, M.B. (2022). *Assessed Skills and Skill Use of Adults with Learning Disabilities in PIAAC.* Retrieved [insert date] from PIAAC Gateway website: [insert link]. Washington, DC.

This project has been funded by the American Institutes for Research through a contract with the National Center for Education Statistics (NCES) of the U.S. Department of Education. This report is based on PIAAC data released in December 2019. The views expressed in this paper do not necessarily reflect the views or policies of the American Institutes for Research, National Center for Education Statistics, or the U.S. Department of Education, nor does mention of trade names, commercial products, or organizations imply endorsement of same by the U.S. Government.

AIR-PIAAC Contact:

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

Author Contact:

Research Allies for Lifelong Learning
Margaret Becker Patterson at
margaret@researchallies.org

Acknowledgments

This paper represents findings from a study commissioned by American Institutes for Research in late 2020. The author gratefully thanks Katie Herz, Saida Mamedova, Jaleh Soroui, and two anonymous reviewers for their helpful comments and insights on the study.

Abstract

A sizeable proportion of adults has learning disabilities (LD); along with having LD, incidence of other disabilities and health conditions is a concern. Adults with LD face educational and employment challenges as well. Little is known about their skills in numeracy and digital literacy and how they use those skills, whether in the workplace or at home. The study's objective was to investigate numeracy/digital literacy skills and skill use for U.S. adults with LD. The study conducted descriptive and regression analyses of 2012-2014-2017 U.S. PIAAC data. Findings are presented on assessed numeracy and digital literacy skills, use of skills at work and at home, relationships of use and skills in both domains and locations, and use of skills among discrete groups of adults with LD. Adults with LD have lower mean numeracy and digital literacy scores than adults in the general population. Use of skills at home adds to variance explained in both numeracy and digital literacy skills; use of digital literacy skills at work does so for digital literacy skills. Findings suggest that using numeracy skills and digital literacy skills matter in gaining – or keeping – the skills themselves. Also, adults with LD appear to have a desire for learning, yet their rates of uncompleted education are high. Knowing relationships of assessed skills with skill use for this population helps in identifying strategies educators can implement to support adult program completion. Further implications of findings are discussed for adult and postsecondary educators, employers and human resource staff, and policy makers.

Assessed Skills and Skill Use of Adults with LD in PIAAC 2012/2014/2017

An estimated 8% of U.S. adults overall have learning disabilities (Patterson & Paulson, 2016). A learning disability (LD) is "a difficulty learning to read, write, speak, and/or calculate numbers stemming from differences in the brain structure that affect the way a person processes information" (Takemoto, 2017. p. 17). LD often coexists with other disabilities and health conditions. Moreover, adults with LD frequently experience educational and employment challenges. Little is known about assessed skill levels of adults with LD, their use of skills in numeracy and digital literacy, and relationships of assessed skills and skill use in a context of adult and postsecondary educational activities (Gal et al., 2020).

Adults with LD may need numeracy skills – practices in everyday life involving mathematics activities (Hogan et al., 2016) – to successfully navigate daily life, help their children with schoolwork, determine shopping costs, or learn other numeracy skills for a sense of accomplishment (Coben & Alkema, 2017; Ginsburg, 2017). Having digital literacy skills also benefits adults with LD in solving problems, that is, "using digital technology, communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks" (PIAAC Expert Group on Problem Solving in Technology-Rich Environments, 2009, p. 9). For example, adults with LD may also employ digital literacy skills to access and use health information (OECD, 2013). By applying numeracy and digital literacy skills, adults with LD may access and interpret health information and use it to manage any coexisting health conditions (Feinberg et al., 2016; Jonas, 2018; Prins & Monnat, 2015).

As the USA "has increasingly become a quantitative, information and technologically heavy society" (Cummins, Yamashita, & Arbogast, 2018, p. 21), with average U.S. PIAAC scores of 257 (Level 2 in numeracy skills) and 274 (Level 1 in digital literacy skills)[i], as of 2014, and many adults unable to take computer-based PIAAC assessments (Rampey et al., 2016),

investigating how numeracy and digital literacy skills of adults with LD compare is important. This study investigates recently measured numeracy/digital literacy skills and use of skills for U.S. adults with learning disabilities at all skill levels in 2012-2014-2017 U.S. Programme for the International Assessment of Adult Competencies (PIAAC) data. Beyond investigating assessed skills and skill use, this paper offers implications for practice. Since U.S. adult and postsecondary education programs and workplaces are not universally designed for adults with LD, ideas on program design and assessment may potentially increase skill levels and use. Also relevant are instructional approaches to support strengthening skills.

Literature Review

Learning disabilities impact the lives of many U.S. adults. In PIAAC, the 2012 LD incidence for adults overall was approximately 8% (Patterson & Paulson, 2016), and in 2012/2014, approximately 12 million U.S. adults with low education attainment reported LD (Patterson, 2019). As Reynolds et al. (2012) and National Research Council (2012) found, it is highly probable that many adults remain undiagnosed and that the true incidence of LD is undetermined. Learning disabilities diagnosed in childhood persist into adulthood (Cortiella & Horowitz, 2014; Roffmann, 2000). National Research Council (2012) indicates learning disabilities are often hereditary and cites the persistence of reading disabilities from childhood into adulthood as reported from multiple longitudinal studies. Coexisting reading and math disabilities affect between 30% and 70% of individuals with either disability (Willcutt et al., 2013).

Alongside LD, a major concern is the incidence of other disabilities and health conditions (McKenna, 2010; Takemoto, 2016). Issues that can affect learning and skill use at any skill level include impairments in executive function (Whetzel, 2016) and health issues (Mellard & Patterson, 2008; Patterson, 2019; Yamashita et al., 2018). The rates of fair or poor health for adults with LD and low education attainment tend to be higher, they have higher rates of permanent disability, and they cite higher rates of vision and auditory difficulties than adults without LD in PIAAC: 2012/2014, even when age is taken into account (Patterson, 2019). Additionally, accessing needed health information online can be hampered through a digital divide experienced by people of color as well as adults with low education attainment, low income, poor health, and no health insurance (Millar et al., 2020). A question remains as to whether adults with LD and similar background characteristics also have low digital literacy skills that could similarly hamper their online access. Additional research is needed to determine the extent of coexisting conditions and strategies that adult and postsecondary (PSE) educators can implement to accommodate needs of adults with multiple conditions as they guide them toward gaining skills and following career pathways (Patterson, 2019).

In addition to issues of incidence and coexisting conditions, adults with LD often experience educational and employment challenges (Housel et al., 2020). Cortiella and Horowitz (2014) found that adults with LD tend to struggle with underachievement and underemployment. Having adequate digital literacy skills may benefit income; Nwakasi and colleagues (2019) found a positive association between earnings and digital literacy skills. Under current pandemic conditions which increasingly require work and learning to occur remotely, the need for digital literacy is suddenly more acute than ever. Bergson-Shilcock (2020) questions whether people

with LD might have fewer digital skills because of challenges such as skill-building opportunities, low income, or other factors. Alternatively, adults with LD, especially younger adults, might be more experienced with digital tools because they use them regularly (Bergson-Shilcock, 2020).

A closely related area to skills themselves is use of skills. Practice engagement theory suggests that more use of skills predicts higher skill levels (Reder, 2019; Reder et al., 2020). Reder et al. (2020) found that use of numeracy skills is positively associated with development of numeracy skills. U.S. adult use of numeracy skills at home is generally high and tends to increase as skill levels rise (Grotlüschen et al., 2016), even as score means in assessed numeracy *skills* are below average (Jonas, 2018). While Coben et al. (2016) consider numeracy skill use, opportunity for numeracy practice, and numeracy skills "mutually reinforcing" (p. 31), Jonas (2018) goes a step further in reporting that numeracy proficiency tends to benefit numeracy practices. Numeracy skills, and even more so numeracy skill use, also appear to predict health-related outcomes and behaviors more than do literacy skills (Jonas, 2018). Having strong skills in numeracy and digital literacy permits adults to access health information, understand health risks, make informed health decisions, and manage health conditions (Feinberg et al., 2016; Jonas, 2018; Prins & Monnat, 2015).

Do similar relationships occur for adults with LD across all skill levels and ranges of skill use? Limited information is available on characteristics associated with adults with LD and low education attainment but less so on adults with LD and higher education attainment. Adults with LD and low education attainment have numeracy and digital literacy skill averages at Level 1. These adults tend to leave high school early more frequently, to have lower rates of employment, to experience higher rates outside the workforce, and to be not in employment, education, or training (NEET), and to have low income at higher rates than low-skilled adults without LD (Patterson, 2019).

The literature is also limited on specific connections of numeracy or digital literacy skills with education and training in which adults with LD participate. About one fourth of U.S. adults with LD and low education attainment attend formal education; 2 in 5 leave programs of education (at any level) uncompleted (Patterson, 2019). Two recent PIAAC studies investigated European data on skills and skill use. Reder et al. (2020) concluded that participation in formal education may not directly support development of numeracy skills. Nwakasi and colleagues (2019) found a surprisingly negative association between participation in education as an adult and digital literacy skills - that is, digital literacy skills did not improve with adult education. Neither of these European PIAAC studies included an LD measure, however, since the LD measure is exclusive to the USA.

Very little research has been done related to the postsecondary activities of transitioning adult learners with LD (Patterson, 2014; Payne, 2010), including investigations of their challenges, supports and accommodations, and educational and career accomplishments (Payne, 2010). Richardson (2014) found that as adult learners transition to postsecondary education, efforts of postsecondary educators to support improvements in both the grades and course pass rates of students with LD are needed. Readiness to learn (Hollinger & Larwin, 2019; Smith et al., 2015) is a potential support for or challenge to participation in postsecondary education. Readiness to

learn is positively associated with numeracy skills (Hollinger & Larwin, 2019) and with skill use in the general population, particularly at home (Smith et al., 2015), but has yet to be examined for adults with LD. Completing postsecondary education and even being overeducated for the available job market may be associated with parental education levels, especially the mother's (Capsada-Munsech; 2020); however, this association has not been tested for adults with LD.

To extend scholarly investigations of the topic, Patterson (2019) recommended that "future researchers could consider how assessed skill levels reflect participant practices in [skill] use at work and at home. They could also disaggregate assessed skills by participant characteristics and background measures to accurately determine the conditions under which the skill levels of adults" with LD are higher or lower. This recommendation informed the decision to look at skills and skill use in discrete groups as described in the fifth research question. This paper expands on the Patterson (2019) study in several ways: 1) it broadens the dataset to include 2017 PIAAC data and compares adults across all PIAAC skill levels (not only those with low education attainment); 2) following 2019 health-related findings, this paper focuses more on coexisting conditions and related health issues; 3) use of numeracy and digital literacy skills at work and at home is a major focus of this paper; and 4) analyses in this paper are more in-depth, involving regression and analyses of discrete groups. Findings from the proposed research inform human resource staff and adult/postsecondary educators in settings where adults have disclosed LD and asked for accommodations, to potentially allow them to adjust approaches to accommodations or instruction accordingly.

The objective of the present study is to investigate numeracy and digital literacy skills and skill use for U.S. adults with LD at all skill levels, employing the most recent 2012-2014-2017 U.S. PIAAC data, through conducting descriptive and regression analyses. Research questions (RQ) are:

1. How do assessed skills in numeracy/digital literacy differ for adults with learning disabilities, compared with the general population, and what is the role of coexisting health and disabling conditions (e.g., vision and auditory difficulties as well as permanent disability)?
2. How does skill use *at work* in numeracy/digital literacy differ for *employed* adults with learning disabilities, compared with the general employed population?
3. How does skill use *at home* in numeracy/digital literacy differ for adults with learning disabilities who are *outside the workforce*, compared with the general population outside the workforce? How does skill use *at home* in numeracy/digital literacy differ for adults with learning disabilities who are *employed*, compared with the general employed population?
4. Controlling for selected demographic and background characteristics, what is the relationship of assessed numeracy skills with numeracy skills use, and of assessed skills in digital literacy with digital literacy skill use, at work or at home for adults with learning disabilities?

5. How does numeracy/digital literacy skill use at work or at home of adults with learning disabilities differ among discrete groups based on covariates (from RQ4) and assessed numeracy and digital skill levels?

Methods

Data and sample. PIAAC:2012 surveyed and assessed 5,010 U.S. adults ages 16 to 65 years. Supplemental data collected from 2014 and 2017 extended the U.S. sample to 12,330 adults and included key subgroups: unemployed adults (ages 16 to 65), young adults (ages 16 to 34), and older adults (ages 66 to 74). In PIAAC adults took surveys and assessments on laptop computers. They completed an extensive background questionnaire and assessments in literacy, numeracy, and digital literacy. Digital literacy was measured by problem-solving in technology-rich environments [PSTRE] items in PIAAC. The background questionnaire (BQ) contains 10 sections of items measuring general information, education background, employment, skill use, personal characteristics, health, and family background.

A restricted-use PIAAC datafile from the combined 2012-2014-2017 data permitted expansion of the power of analyses through a larger sample and to ensuring that accurate sample weights for all three years of data collection were employed in analyses. The full sample from PIAAC:2012/2014/2017 was limited for this paper to 1,130 U.S. adults with LD and 10,820 adults with no LD (*N* 11,950), as determined from a variable in PIAAC's background questionnaire, I_Q08USX3 (self-reported diagnosis of LD). Although most adults with LD taking assessments (n = 890, or 87.9%) took computer-based assessments, 120 (12.1%) took paper-based assessments. Of those, 100 took a numeracy assessment on paper, and 110 reported having no computer experience.

PIAAC:2012/2014/2017 data collection employed a complex sampling design to ensure representativeness in the population (Hogan et al., 2016). Sample weights are applied to ensure that respondents in the sample represent an accurate population proportion and that standard errors reflect variability estimated in the population rather than in the sample. Replicate weights facilitate calculating unbiased estimates and standard errors. More detail on sampling, weighting, background questionnaire administration, and assessments is available in Hogan et al. (2016).

PIAAC skill variables. Plausible values are estimated in means analyses of assessed numeracy and PSTRE skills, with 10 plausible values employed per content domain. Scores in both domains range from 0 to 500 and are classified into one of five levels for numeracy and four levels for PSTRE. Numeracy levels are below Level 1 (0-175), Level 1 (176-225), Level 2 (226-275), Level 3 (276-325), and Levels 4 / 5 (326-500), according to Rampey et al. (2016). In PSTRE, levels include below Level 1 (0-240), Level 1 (240-290), Level 2 (291-340), and Level 3 (341-500).

PIAAC skill use variables. Analyses in this paper rely on multiple PIAAC BQ items, including information on how often adults engage in numeracy-related or digital-literacy-related activities at home or in the workplace. Responses range from "never" to "every day". PIAAC respondents are asked about six numeracy activities and seven digital literacy activities. The 26 at-home and at-work use items with numeracy and digital literacy components are shown in Table 1.

Table 1.

Items for Use of Numeracy and Digital Literacy Skills at Home or At Work

At Work Item	At Home Item	Wording: How often do you usually…
G_Q03b	H_Q03b	Calculate prices, costs, or budgets?
G_Q03c	H_Q03c	Use or calculate fractions, decimals, or percentages?
G_Q03d	H_Q03d	Use a calculator - either hand-held or computer based?
G_Q03f	H_Q03f	Prepare charts, graphs, or tables?
G_Q03g	H_Q03g	Use simple algebra or formulas? *
G_Q03h	H_Q03h	Use more advanced math or statistics such as calculus, complex algebra, trigonometry, or use of regression techniques?
G_Q05a♯	H_Q05a♯	Use e-mail?
G_Q05c♯	H_Q05c♯	Use the internet to better understand issues related to, for example, your health or illnesses, financial matters, or environmental issues / to your work?
G_Q05d♯	H_Q05d♯	Conduct transactions on the internet, for example buying or selling products or services, or banking?
G_Q05e♯	H_Q05e♯	Use spreadsheet software, for example Excel?
G_Q05f♯	H_Q05f♯	Use a word processor, for example Word?
G_Q05g♯	H_Q05g♯	Use a programming language to program or write computer code?
G_Q05h♯	H_Q05h♯	Participate in real-time discussions on the internet, for example online conferences, or chat groups?

Notes: frequency of responses includes never, less than once a month, less than once a week but at least once a month, at least once a week but not every day, every day. * According to PIAAC BQ, as cited in Curry (2017, p. 4), "By simple algebra or formula, we mean a mathematical rule that enables us to find an unknown number or quantity, for example a rule for finding an area when knowing length and width, or for working out how much more time is needed to travel a certain distance if speed is reduced." ♯ Technology variables contained substantial missing data because many adults had reported earlier not ever using a computer so were legitimately not asked the question. For RQ4 regression analyses, composites of these variables were employed to maximize use of the sample for regression analyses.

Source: U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

Research design and analyses. Quantitative PIAAC data were analyzed through calculation of descriptive statistics, regression modelling, and examination of group differences for discrete groups representing numeracy/digital literacy skill use at home or at work, with controls. Data were analyzed in SPSS 26 employing macro syntax from IDB Analyzer 4.0.35, with sample and replicate weights applied in all analyses. All analyses were descriptive or predictive, and causality should not be inferred.

Research questions are:

1. How do assessed skills in numeracy/digital literacy differ for adults with learning disabilities, compared with the general population, and what is the role of coexisting health and disabling conditions (e.g., vision and auditory difficulties as well as permanent disability)?

2. How does skill use *at work* in numeracy/digital literacy differ for *employed* adults with learning disabilities, compared with the general employed population?
3. How does skill use *at home* in numeracy/digital literacy differ for adults with learning disabilities who are *outside the workforce*, compared with the general population outside the workforce? How does skill use *at home* in numeracy/digital literacy differ for adults with learning disabilities who are *employed*, compared with the general employed population?
4. Controlling for selected demographic and background characteristics, what is the relationship of assessed numeracy skills with numeracy skills use, and of assessed skills in digital literacy with digital literacy skill use, at work or at home for adults with learning disabilities?
5. How does numeracy/digital literacy skill use at work or at home of adults with learning disabilities differ among discrete groups based on covariates (from RQ4) and assessed numeracy and digital skill levels?

To address RQ1, means, standard deviations (*SD*), percentages, and their associated standard errors (*SE*) were calculated for numeracy and PSTRE skills. Mean scores of adults with and without LD were tested for statistical and practical significance, with Cohen's *d* as effect size representing magnitude of mean differences from overall population score means. To determine the role of health and other disabilities in skill levels, numeracy and PSTRE means were compared by health status (I_Q08), difficulty seeing print (I_Q08USX1), difficulty hearing (I_Q08USX2), medical insurance status (I_Q10BUSX1), and employment status (C_Q07, which contains an indicator of permanent disability). Means of adults with and without LD are tested for practical significance, using Cohen's *d* as an effect size, across levels of the five health/disabilities variables (e.g., are mean numeracy skills for adults with LD and with fair/poor health higher than for adults without LD and with fair/poor health?). Cohen's *d* effects are interpreted as small (0.20 to 0.49), medium (0.50 to 0.79), or large (>=0.80).

In RQ2, means for composites of numeracy skill use (NUMWORK_WLE_CA) and digital literacy skill use (ICTWORK_WLE_CA) were compared in the workplace for adults who are employed, as measured in employment status variable C_D05. In RQ3 a similar means comparison occurred using composites for numeracy skill use at home (NUMHOME_WLE_CA) and digital literacy skill use at home (ICTHOME_WLE_CA) for individuals with and without LD who are out of the workforce, as measured in C_D05 (employment status variable). Analyses of numeracy / digital literacy skill use at home were then repeated for adults with and without LD who are employed. For both RQs, employing a categorical numeracy or digital literacy skill use variable, rather than its continuous counterpart, accounted for adults not responding to any skill use measures.

Use of numeracy skill or PSTRE skills at work or at home were also believed to be relevant predictors of skills that may add to the variance of models. To address RQ4, a series of four linear regression models (A through D) were analyzed. For models A and B, the file was limited to those with LD who are employed (*n* 570). For models C and D, the full LD file was used (*n* 1,120). In preparation for use in regression analysis, categorical variables with several levels were recoded to two levels. Ethnic status (RACETHN_4CAT), as a measure of socioeconomic

status for models on use of skills at home, was recoded into dichotomous PeopleofColor, with levels of Black/Hispanic/All others and white. Health status (I_Q08) was recoded into dichotomous I_Q08R, with levels of excellent/very good/good and fair/poor health and employed in digital literacy models. Model A included seven variables representing demographic and background characteristics (i.e., age [AGE_R], gender [GENDER_R], education attainment level [B_Q01A], monthly earnings [EARNMTHALLDCL], and vision difficulty [I_Q08USX1]), as well as readiness to learn (READYTOLEARN) and uncompleted education (B_Q03A). The same seven variables were included in Model B, with two exceptions: urban status (URBAN_12CAT) and health status (I_Q08R) replaced readiness to learn (READYTOLEARN) and vison difficulty (I_Q08USX1). Model C included nine variables: age, education attainment, gender, ethnic status, vision difficulty, and the status of "not in education or training" (NEET) and added readiness to learn, uncompleted education and wanting more training but not starting it (B_Q26A). Model D contained nine variables: age, education attainment, urban status, gender, health, ethnic status, and NEET, along with uncompleted education and wanting more training but not starting it.

A second set of regression models A through D included the same variables from the first analyses as controls plus one skill use variable (NUMWORK_WLE_CA for Model A, ICTWORK_WLE_CA for Model B, NUMHOME_WLE_CA for Model C, and ICTHOME_WLE_CA for Model D), to determine any added variance from skill use at work or at home. In deciding on variables, missingness of variables was reviewed, to ensure no systematic bias occurred (or that populations were validly skipped) between these variables. Preserving a balance between including theoretically relevant variables and adequate power for analysis was important. Before regression analyses, variables with significant missing data or not meeting regression assumptions (e.g., multicollinearity, variable level) were removed or recoded. The unweighted sample sizes for regression models were: Model A *n* 400, Model B *n* 330, Model C *n* 870, and Model D *n* 600. Effect sizes, employing r, were calculated for t-test statistics as small (0.10 to 0.29), medium (0.30 to 0.49), or large (>=0.50).

In addressing RQ5, 14 discrete groups are identified from PIAAC data, based on regression model results from RQ4:

- numeracy for employed adults with LD, in three groups;
- digital literacy for employed adults with LD, in three groups;
- numeracy at home for all adults with LD, in four groups; and
- digital literacy at home for all adults with LD, in four groups

Because of the close alignment of education attainment with assessed skill levels in preliminary regression models, discrete groups were categorized based on education attainment (using B_Q01A_C, with low [less than high school], medium [high school], and high [postsecondary]attainment) and on grouped numeracy skill levels (i.e., level 2 or less and level 3 or higher) for numeracy skill use or by PSTRE skill levels (i.e., below level 1 and level 1 and higher) for digital literacy skill use. Skill levels were determined from 10 plausible values per skill domain, with at least nine if not all 10 plausible values required to be in the score range for the category (i.e., with 275 as the cut point for numeracy and 240 as the cut point for PSTRE) to maximize group sizes.

Then the extent of numeracy and digital literacy skill-use patterns, using the variables in Table 1, were analyzed categorically for the 14 groups. Finally, characteristics of each discrete group were described. For employed adults with LD, these characteristics included: age (AGE_R), gender (GENDER_R), monthly earnings in deciles (EARNMTHALLDCL), parents' highest education (PARED), uncompleted education (B_Q03a), age leaving uncompleted education (B_Q03C1), participation in distance education (B_Q12A), reason for not pursuing formal education (B_Q26B), if applicable, taking a class/tutoring in basic skills, GED, or other HSE (B_Q27AUSX, B_Q27BUSX, B_Q27CUSX), hours per week working currently (D_Q10_C), not feeling challenged at work (F_Q07A), need for more training at work (F_Q07B), use of a computer, level of computer use at work, and computer skills needed at work (G_Q04_T, G_Q06, and G_Q07), and current occupation and industry (ISCO08_CUS_C, ISIC4_CUS_C).

Characteristics of the eight groups at home included: age (AGE_R), gender (GENDER_R), monthly earnings in deciles (EARNMTHALLDCL), parents' highest education (PARED), uncompleted education (B_Q03a), age leaving uncompleted education (B_Q03C1), participation in distance education (B_Q12A), reason for not pursuing formal education (B_Q26B), if applicable, taking a class/tutoring in basic skills, GED, or other HSE (B_Q27AUSX, B_Q27BUSX, B_Q27CUSX), reason for the end of the last job (E_Q10), if applicable, hours per week working at last job (E_Q09_C), if applicable, social trust variables (I_Q07A and I_Q07B), and last job occupation and industry (ISCO08_LUS_C, ISIC4_LUS_C).

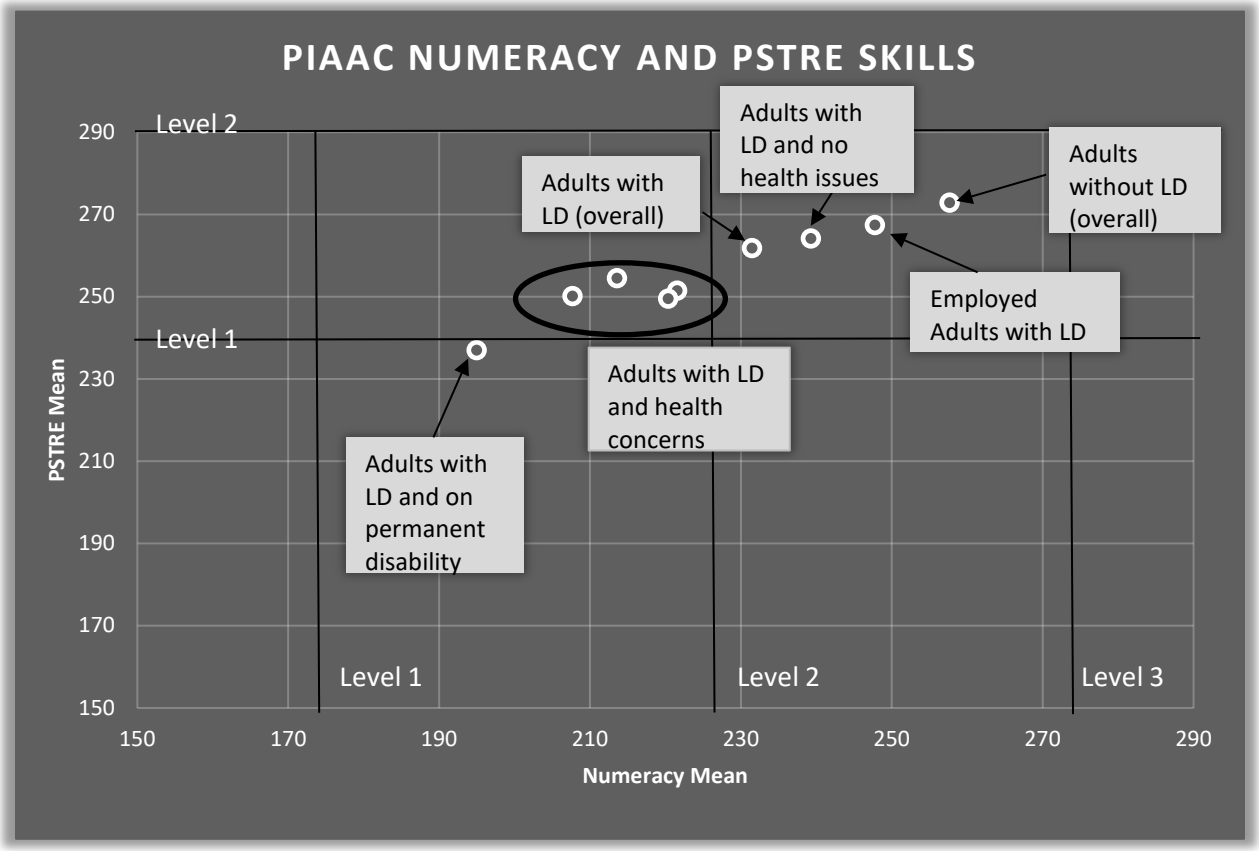
Findings

Assessed Skills

Adults who reported being diagnosed with LD have significantly lower mean scores in numeracy and digital literacy, respectively, than their counterparts without LD, though scoring in the same broad skill level. As displayed in Figure 1, the average numeracy score for adults reporting an LD diagnosis overall ("with LD") is 231.5 (*SE* 2.8, *SD* 57.5, *SE* 1.6). The average numeracy score for adults without LD is 257.7 (*SE* 1.0, *SD* 55.9, *SE* 0.7). Although these numeracy score means are both in Level 2, numeracy averages for adults with LD are moderately lower (*d* -0.46). PSTRE scores for adults with LD (see Figure 1) average 261.8 (*SE* 2.4, *SD* 42.9, *SE* 1.7). PSTRE scores for adults without LD average 272.8 (*SE* 0.9, *SD* 44.6, *SE* 0.7), a slightly higher mean difference (*d* -0.25) even though both PSTRE averages are in Level 1.

Figure 1

Scatterplot of Numeracy and PSTRE Score Means by LD Status and by Coexisting Conditions



Source: U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

Figure 1 also displays numeracy and PSTRE skill average scores, in descending order, for adults with LD who are employed; with LD and no health issues; with LD and health concerns, such as fair or poor health, vision difficulty, hearing difficulty, and no medical insurance; and with LD and on permanent disability. Employed adults with LD – 48% of adults with LD – and adults with no health issues and LD have higher mean scores in numeracy and digital literacy than adults with LD and health concerns. Adults with LD and on permanent disability have the lowest scores. Adults with LD have approximately three times the incidence of permanent disability and approximately twice the incidence of fair/poor health, visions difficulties, and hearing difficulties as adults without LD. Medical insurance rates are similar by LD status.

Tables 2 and 3 present numeracy and PSTRE score means, respectively, by LD status and coexisting conditions. For adults with LD, vision difficulties and permanent disability status are coexisting conditions that are significantly associated with lower numeracy scores. Adults with LD and vision difficulties have significantly lower scores (*d* 0.55) than adults with LD and no vision difficulties, and adults with LD and on permanent disability have lower scores than employed adults with LD (*d* 0.97) and all others with LD (*d* 0.54). Otherwise, all mean numeracy score differences for adults with LD by coexisting conditions are small. For adults with no LD, fair or poor health (*d* 0.64), vision difficulties (*d* 0.58), and lack of medical insurance (*d* 0.51) are

also conditions that are significantly associated with lower numeracy scores, all at medium magnitudes. Adults with no LD on permanent disability status also have lower numeracy scores than employed adults with no LD (*d* 0.89) and all others with no LD (*d* 0.64). Subgroup numeracy score differences by LD status are also small. These differences indicate health issues have greater association with numeracy score differences than does LD status. Still, given higher incidence rates of permanent disability and health issues for adults with LD and that numeracy scores are lower for adults with LD in every subgroup, numeracy skill levels are clearly a concern for adults with LD, particularly those with coexisting disabilities that prevent employment.

Table 2

Numeracy Score Means by LD Status and by Coexisting Conditions

LD Status	Subgroup	Percent (%)	*SE*	Mean	*SE*	*SD*	*SE*	Unweighted *n*[a]	*d*
LD	Good Health	69.6	2.1	239.3	3.0	54.4	2.1	780	0.45[†]
	Fair/Poor Health	30.4	2.1	213.6	4.9	60.3	2.8	340	
	Vision Difficulty	22.6	1.3	207.7	4.7	56.1	3.4	250	0.55[†]
	No Vision Difficulty	77.4	1.3	238.7	3.1	55.9	1.8	870	
	Hearing Difficulty	19.4	1.7	221.6	5.8	57.7	3.9	200	0.21[†]
	No Hearing Difficulty	80.6	1.7	233.8	2.9	57.2	1.9	920	
	Medical Insurance	81.7	1.4	233.8	3.1	58.8	1.7	870	0.25[†]
	No Medical Insurance	18.3	1.4	220.4	5.5	49.8	3.4	250	
	On Permanent Disability	15.4	1.4	195.0	5.1	56.3	3.6	170	0.97[b]
	Employed	48.4	2.0	247.8	3.7	52.2	2.0	460	0.54[c]
	All Others	36.2	1.7	225.6	4.1	56.2	3.1	490	0.41[d]
No LD	Good Health	84.8	0.5	263.0	1.0	54.0	0.7	9,140	0.64[†]
	Fair/Poor Health	15.2	0.5	227.6	1.9	56.7	1.5	1,680	0.24[‡]
	Vision Difficulty	11.5	0.3	228.6	2.1	57.8	1.7	1,190	0.58[†]
	No Vision Difficulty	88.5	0.3	261.4	1.0	54.6	0.6	9,630	0.37[‡]
	Hearing Difficulty	9.6	0.4	249.5	2.5	56.1	1.8	980	0.16[†]
	No Hearing Difficulty	90.4	0.4	258.5	1.0	55.8	0.8	9,850	0.49[‡]
	Medical Insurance	83.4	0.5	262.3	1.0	54.9	0.7	8,720	0.51[†]
	No Medical Insurance	16.6	0.5	234.4	2.3	55.1	1.6	2,060	0.27[‡]
	On Permanent Disability	4.5	0.2	216.0	3.6	53.4	2.8	460	0.89[e] 0.38[‡]
	Employed	63.7	0.6	264.3	1.2	55.1	0.8	6,120	0.64[f] 0.31[‡]
	All Others	31.8	0.6	250.4	1.5	54.4	1.1	4,250	0.25[g] 0.45[‡]

Note. [a] Sample and replicate weights were applied in all analyses, and 10 plausible values were used to estimate score means. [b] magnitude of difference in mean scores for LD and on permanent disability with employed LD. [c] magnitude of difference in mean scores for LD and on permanent disability with LD all others. [d] magnitude of difference in mean scores for LD employed and LD all others. [e] magnitude of difference in mean scores for no LD and on permanent disability with no LD employed. [f] magnitude of difference in mean scores for no LD and on permanent disability with no LD all others. [g] magnitude of difference in mean scores for no LD employed and no LD all others. [†] magnitude of difference in mean scores between levels of a coexisting condition (e.g., adult with vision difficulty compared with adult with no vision difficulty). [‡] magnitude of difference in mean scores of LD by a

coexisting condition compared with no LD by the same coexisting condition (e.g., LD and fair/poor health compared with no LD and fair/poor health, or LD and vision difficulty compared with no LD and vision difficulty).
Source: U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

For PSTRE, as shown in Table 3, having LD and permanent disability is significantly associated with lower mean scores (*d* 0.75 and 0.53). Otherwise, all mean PSTRE score differences for adults with LD and coexisting conditions are small. Adults with no LD on permanent disability status also have lower PSTRE scores than employed adults with no LD (*d* 0.89) and all others with no LD (*d* 0.72). Subgroup PSTRE score differences by LD status are also small. For adults with LD, differences in PSTRE skill levels appear to be less of a concern than numeracy differences, except for those with coexisting disabilities that prevent employment.

Table 3
PSTRE Score Means by LD Status and by Coexisting Conditions

LD Status	Subgroup	Percent (%)	*SE*	Mean	*SE*	*SD*	*SE*	Unweighted *n*[a]	*d*
LD	Good Health	76.6	2.4	264.1	2.7	42.4	1.9	630	0.22†
	Fair/Poor Health	23.4	2.4	254.5	4.6	43.6	3.1	190	
	Vision Difficulty	16.8	1.4	250.1	5.0	42.7	4.3	130	0.33†
	No Vision Difficulty	83.2	1.4	264.3	2.7	42.5	1.8	690	
	Hearing Difficulty	17.6	1.9	251.4	5.6	42.0	4.0	130	0.30†
	No Hearing Difficulty	82.4	1.9	264.1	2.5	42.7	1.8	690	
	Medical Insurance	82.3	1.7	264.2	2.6	43.4	1.7	630	0.36†
	No Medical Insurance	17.7	1.7	249.5	4.6	37.4	3.4	180	
	On Permanent Disability	8.2	1.2	237.0	7.2	39.3	5.8	60	0.75[b]
	Employed	55.7	2.1	267.4	3.1	41.3	2.2	380	0.53[c]
	All Others	36.1	2.0	258.9	3.5	43.8	2.5	380	0.20[d]
No LD	Good Health	88.5	0.5	275.2	0.8	43.7	0.7	7,850	0.47†
	Fair/Poor Health	11.5	0.5	254.1	2.3	46.3	1.4	1,070	0.01‡
	Vision Difficulty	9.0	0.4	252.9	2.2	44.7	1.5	790	0.49†
	No Vision Difficulty	91.0	0.4	274.7	0.9	44.1	0.7	8,140	0.06‡
	Hearing Difficulty	8.4	0.4	262.1	2.4	45.7	2.0	710	0.26†
	No Hearing Difficulty	91.6	0.4	273.7	0.9	44.3	0.6	8,220	0.24‡
	Medical Insurance	85.1	0.5	275.3	0.9	44.3	0.6	7,320	0.38†
	No Medical Insurance	14.9	0.5	258.6	2.3	43.7	1.4	1,570	0.22‡
	On Permanent Disability	2.9	0.2	237.5	4.0	42.7	2.6	230	0.89[e] 0.01‡
	Employed	66.7	0.7	276.2	1.0	44.0	0.9	5,320	0.72[f] 0.21‡
	All Others	30.4	0.7	268.6	1.5	44.1	1.0	3,380	0.17[g] 0.22‡

Note. [a] Sample and replicate weights were applied in all analyses, and 10 plausible values were used to estimate score means. [b] magnitude of difference in mean scores for LD and on permanent disability with employed LD. [c] magnitude of difference in mean scores for LD and on permanent disability with LD all others. [d] magnitude of difference in mean scores for LD employed and LD all others. [e] magnitude of difference in mean scores for no LD and on permanent disability with no LD employed. [f] magnitude of difference in mean scores for no LD and on

permanent disability with no LD all others. [g] magnitude of difference in mean scores for no LD employed and no LD all others. [†] magnitude of difference in mean scores between levels of a coexisting condition (e.g., adult with vision difficulty compared with adult with no vision difficulty). [‡] magnitude of difference in mean scores of LD by a coexisting condition compared with no LD by the same coexisting condition (e.g., LD and fair/poor health compared with no LD and fair/poor health, or LD and vision difficulty compared with no LD and vision difficulty).
Source: U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

Skill Use at Work

In numeracy, employed adults, whether with or without LD, have similar levels of skill use. Employed adults with LD have a mean numeracy skill use score of 2.5 (*SE* 0.1, *SD* 1.8). This use score indicates that on average they employ numeracy skills at work at least once a month but not every week. The numeracy skill use average at work for employed adults with no LD is similar (2.8, *SE* 0.0, *SD* 1.7).

In using digital literacy skills, employed adults with no LD have significantly higher average use (3.0, *SE* 0.0, *SD* 1.6) than employed adults with LD (2.5, *SE* 0.1, *SD* 1.7), though the difference is small (*d* 0.30). Employed adults with no LD tend to use digital literacy skills at least once a week but not daily. In contrast, those with LD use digital literacy skills at work at least once a month but not every week, at rates similar to their numeracy skill use.

Skill Use at Home

Employment also appears to provide a slight advantage in use of numeracy skills at home for both adults with and without LD who are employed, in comparison with adults with LD who are out of the labor force. Adults with LD who are out of the labor force report using numeracy skills at home significantly less often (2.5, *SE* 0.1, *SD* 1.7) than employed adults with LD do (3.1, *SE* 0.1, *SD* 1.6), though the difference is small (*d* 0.36). Adults with LD not in the labor force tend to use numeracy skills at least once a month at home while those who are employed do so at least weekly. Adults with no LD tend to use numeracy skills at home at similar rates, and at least weekly on average, whether they are out of the labor force (3.2, *SE* 0.0, *SD* 1.5) or employed (3.3, *SE* 0.0, *SD* 1.5).

Results are similar for digital literacy skill use at home. Adults with LD who are out of the labor force report using digital literacy skills at home significantly less often (2.6, *SE* 0.1, *SD* 1.5) than employed adults with LD do (3.1, *SE* 0.1, *SD* 1.4); again, the difference is small (*d* 0.34). Adults with LD not in the labor force tend to use digital literacy skills at least once a month at home while those who are employed do so at least weekly. Adults with no LD tend to use digital literacy skills at home at similar rates, and at least weekly on average, whether they are out of the labor force (3.1, *SE* 0.0, *SD* 1.4) or employed (3.3, *SE* 0.0, *SD* 1.3).

Relationships of Skills with Skill Use

Numeracy at work. Model A results, as shown in Table 4, indicate that seven covariates explain approximately 35% of the variance in numeracy skills of employed adults with LD. Use of numeracy at work does not add practical significance to how the model predicts numeracy skill levels. In predicting numeracy skills for employed adults with LD, education attainment, monthly earnings, and uncompleted education have small effects, with education attainment as the strongest predictor (see Table 4). Age, readiness to learn, gender, and vision difficulty were not significant predictors in the model. Holding background predictors constant, for each

increasing level of use of numeracy skills, the numeracy skill score of an employed adult with LD would be expected to increase less than two points.

Table 4

Regression Results for Numeracy Skills (Model A - At Work)

Predictor	*B*	*SE B*	*β*	*SE β*	Unweighted n[a]	R^{2b}	*r*[c]
Constant (A1)	145.27	14.43	-	-	400	0.35	
Age	0.13	0.25	0.03	0.06			0.02
Education Attainment	7.48	1.04	0.42	0.06			0.26*
Monthly Earnings	4.35	1.29	0.22	0.07			0.12*
Readiness to Learn	3.01	2.45	0.06	0.05			0.04
Gender (Female)	-4.14	5.32	-0.04	0.05			-.0.03
(No) Vision Difficulty	17.30	8.39	0.12	0.06			0.07
(No) Uncompleted Education	-15.39	5.64	-0.14	0.05			-0.10*
Constant (A2)	144.84	14.59	-	-	400	0.35	
Age	0.13	0.26	0.03	0.06			0.04
Education Attainment	7.48	1.03	0.42	0.06			0.26*
Monthly Earnings	3.91	1.32	0.20	0.07			0.11*
Readiness to Learn	2.55	2.47	0.05	0.05			0.05
Gender (Female)	-4.14	5.33	-0.04	0.05			-0.04
(No) Vision Difficulty	16.62	8.48	0.12	0.06			0.07
(No) Uncompleted Education	-15.14	5.65	-0.14	0.05			-0.10*
Numeracy Skill Use	1.72	1.31	0.06	0.04			0.05

Note. [a] Sample and replicate weights were applied in all analyses, and 10 plausible values were used to estimate score means. [b] R^2 statistic represents the model variance. [C] *r* represents the effect size for individual predictors, based on the standardized coefficient; * represents a small effect, ** a medium effect, and *** a large effect for *r*.
Source: U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

Digital literacy at work. Model B results, as shown in Table 5, indicate that seven covariates and the use of digital literacy at work explain approximately 30% of the variance in digital literacy skills of employed adults with LD. Education attainment, digital literacy skill use, uncompleted education, and age are the strongest predictors of digital literacy skills for employed adults with LD, all with small effects (see Table 5). Monthly earnings, urban status, gender, and health status were not significant predictors in the model. Holding background predictors constant, for each increasing level of use of digital literacy skills at work, the PSTRE skill score of an employed adult with LD would be expected to increase five points.

Table 5

Regression Results for PSTRE Skills (Model B - At Work)

Predictor	*B*	*SE B*	*β*	*SE β*	Unweighted n[a]	R^{2b}	*r*[c]
Constant (B1)	239.89	10.05	-	-	330	0.25	
Age	-0.50	0.26	-0.15	.07			0.07
Education Attainment	6.19	0.85	0.43	0.06			0.28*

Monthly Earnings	1.74	1.20	0.12	0.08			0.05
Urban Status	-0.40	0.22	-0.11	0.06			-0.07
Gender (Female)	0.48	5.57	0.01	0.07			0.00
Health (Fair/Poor)	-0.27	7.78	0.00	0.08			-0.00
(No) Uncompleted Education	-16.25	6.08	-0.20	0.07			0.10*
Constant (B2)	244.40	12.70	-	-	250	0.30	
Age	-0.56	0.28	-0.17	0.08			-0.10*
Education Attainment	5.17	1.08	0.37	0.07			0.22*
Monthly Earnings	0.67	1.36	0.04	0.09			0.02
Urban Status	-0.27	0.29	-0.07	0.08			-0.04
Gender (Female)	-1.34	6.50	-0.02	0.08			0.01
Health (Fair/Poor)	-1.12	8.71	-0.01	0.09			-0.01
(No) Uncompleted Education	-14.71	5.97	-0.18	0.07			-0.11*
Digital Literacy Skill Use	5.17	2.15	0.22	0.09			0.11*

Note. [a] Sample and replicate weights were applied in all analyses, and 10 plausible values were used to estimate score means. [b] R^2 statistic represents the model variance. [C] *r* represents the effect size for individual predictors, based on the standardized coefficient; * represents a small effect, ** a medium effect, and *** a large effect for *r*. *Source:* U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

Numeracy at home. Model C results, as shown in Table 6, indicate that nine covariates and use of numeracy at home explain approximately 47% of the variance in numeracy skills of adults with LD. In predicting numeracy skills for adults with LD, education attainment, people of color, and numeracy skill use at home have small effects (see Table 6). Age, readiness to learn, gender, vision difficulty, uncompleted education, and desire for more training were not significant predictors in the model. Holding background predictors constant, for each increasing level of use of numeracy skills, the numeracy skill score of an adult with LD would be expected to increase seven points.

Table 6

Regression Results for Numeracy Skills (Model C - At Home)

Predictor	*B*	*SE B*	*β*	*SE β*	Unweighted n[a]	R^{2b}	*r*[c]
Constant (C1)	178.97	10.94	-	-	870	0.44	
Age	0.12	0.15	0.03	0.04			0.02
Education Attainment	7.26	0.74	0.40	0.04			0.24*
Readiness to Learn	5.52	1.80	0.11	0.04			0.07
Gender (Female)	-10.63	3.27	-0.09	0.03			-0.08
(No) Vision Difficulty	12.88	5.27	0.10	0.04			0.06
People of Color	-28.84	4.64	-0.23	0.04			-0.15*
(No) Uncompleted Education	-12.29	5.00	-0.10	0.04			-0.06
(No) Desire for More Training	-9.88	4.11	-0.08	0.03			-0.06
NEET	-19.85	4.81	-0.16	0.04			-0.10*
Constant (C2)	169.87	11.00	-	-	870	0.47	
Age	0.12	0.15	0.03	0.04			0.02
Education Attainment	6.33	0.70	0.35	0.04			0.21*
Readiness to Learn	3.19	1.89	0.06	0.04			0.04

Gender (Female)	-11.10	3.14	-0.10	0.03			-0.08
(No) Vision Difficulty	10.50	5.16	0.08	0.04			0.05
People of Color	-28.53	4.38	-0.22	0.03			-0.16*
(No) Uncompleted Education	-10.95	4.82	-0.09	0.04			-0.06
(No) Desire for More Training	-6.15	4.13	-0.05	0.03			-0.04
NEET	-17.87	4.59	-0.14	0.04			-0.09
Numeracy Skill Use	7.33	1.55	0.21	0.04			0.12*

Note. [a] Sample and replicate weights were applied in all analyses, and 10 plausible values were used to estimate score means. [b] R^2 statistic represents the model variance. [C] *r* represents the effect size for individual predictors, based on the standardized coefficient; * represents a small effect, ** a medium effect, and *** a large effect for *r*. *Source:* U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

Digital literacy at home. Model D results, as shown in Table 7, indicate that nine covariates and the use of digital literacy at home explain approximately 37% of the variance in digital literacy skills of adults with LD. Predictors of digital literacy skills for adults with LD with small effects are education attainment, use of digital literacy skills at home, and people of color (see Table 7). Age, urban status, gender, health status, uncompleted education, desire for more training, and NEET were not significant predictors in the model. Holding background predictors constant, for each increasing level of use of digital literacy skills at home, the PSTRE skill score of an adult with LD would be expected to increase nearly nine points.

Table 7

Regression Results for PSTRE Skills (Model D - At Home)

Predictor	*B*	*SE B*	*β*	*SE β*	Unweighted n[a]	R^{2b}	*r*[c]
Constant (D1)	259.94	8.73	-	-	600	0.31	
Age	-0.52	0.17	-0.17	0.06			-0.09
Education Attainment	5.97	0.77	0.40	0.04			0.26*
Urban Status	-0.38	0.17	-0.10	0.05			-0.06
Gender (Female)	-2.29	4.53	-0.03	0.05			-0.01
Health (Fair/Poor)	-3.15	5.60	-0.03	0.06			-0.02
People of Color	-19.39	5.81	-0.20	0.06			-0.15*
(No) Uncompleted Education	-12.69	5.28	-0.15	0.06			-0.07
(No) Desire for More Training	-11.88	3.53	-0.14	0.04			-0.10*
NEET	-12.32	4.62	-0.11	0.04			-0.07
Constant (D2)	245.70	11.01	-	-	490	0.37	
Age	-0.53	0.19	-0.18	0.06			-0.09
Education Attainment	4.17	0.80	0.28	0.05			0.17*
Urban Status	-0.26	0.20	-0.07	0.06			-0.04
Gender (Female)	-3.18	4.68	-0.04	0.05			-0.02
Health (Fair/Poor)	-2.58	5.54	-0.03	0.06			-0.01
People of Color	-20.88	5.67	-0.21	0.05			-0.16*
(No) Uncompleted Education	-9.02	4.77	-0.10	0.05			-0.06
(No) Desire for More Training	-8.11	3.71	-0.10	0.04			-0.07

NEET	-7.06	4.88	-0.06	0.04	-0.05
Digital Literacy Skill Use	8.73	2.02	0.29	0.06	0.14*

Note. [a] Sample and replicate weights were applied in all analyses, and 10 plausible values were used to estimate score means. [b] R^2 statistic represents the model variance. [C] *r* represents the effect size for individual predictors, based on the standardized coefficient; * represents a small effect, ** a medium effect, and *** a large effect for *r*. *Source:* U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

Skill Use for Discrete Groups

Numeracy skill use. In describing numeracy skill use of employed adults with LD, three groups were identified: *low* numeracy (less than high school attainment and level 2 or below numeracy skills), *minimal* numeracy (high school attainment and level 2 or below numeracy skills), and *high* numeracy (postsecondary attainment and level 3 or higher numeracy skills). The same descriptors were used for the first three groups of adults with LD in considering numeracy skill use at home: *low* numeracy, *minimal* numeracy, and *high* numeracy; an additional *maintaining* numeracy group was available in the broader dataset (postsecondary attainment and level 2 or below numeracy skills). Table 8 presents characteristics of adults with LD by numeracy group. Higher numeracy skills and skill use tended to be associated with increased age at work, higher monthly earnings (at work or at home), higher parental education attainment (at work or at home), increased distance education participation (at work or at home), more hours of weekly work (at work), lower incidence at home of uncompleted education, and greater social trust at home. Also, employed adults with LD tended to work most frequently in restaurants, landscaping, construction, and retail. In the *high* numeracy group, they also worked in higher education, hospitals, community services, and government.

Table 8

Characteristics of Adults with LD by Numeracy Group

Location	Characteristic	Low Numeracy	Minimal Numeracy	Maintaining Numeracy[a]	High Numeracy
At Work	*n*	80	210		60
	Age – mean years (*SD*)	31.9 (13.6)	33.4 (11.4)	‡	39.7 (13.3)
	Gender – male (%)	61.3	56.9	‡	59.0
	Monthly earnings – median decile	9th	7th	‡	4th
	Parent education - mode	High school	High school	‡	Postsecondary
	Uncompleted education (%)	40.7	37.8	‡	25.0
	Age leaving uncompleted education – mean (SD)	‡	23.6 (7.1)	‡	24.5 (6.7)!
	Distance education participation (%)	3.3	13.7	‡	24.6
	Basic skills participation (%)	11.3	11.1!	‡	‡
	HSE participation (%)	15.1	6.6!	‡	‡
	Weekly hours worked - mean (SD)	28.2 (17.2)	35.2 (14.5)	‡	38.9 (13.1)
	Not challenged at work (%)	85.0	89.6	‡	88.5

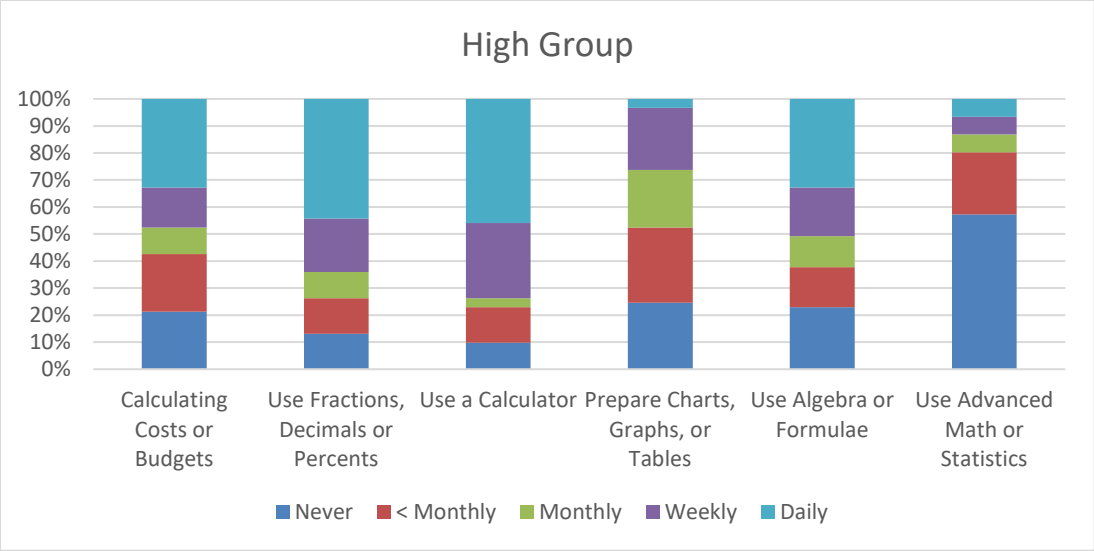
Location	Characteristic	Low Numeracy	Minimal Numeracy	Maintaining Numeracy[a]	High Numeracy
	Need more training (%)	23.8	25.2	‡	29.5
	Computer use at work is straightforward (%)	87.5!	64.5	‡	19.3
	Computer use at work is moderate (%)	10.0!	30.6	‡	64.9
At Home	*n*	280	440	80	80
	Age – mean years (*SD*)	34.6 (16.9)	34.7 (13.3)	44.9 (14.9)	41.3 (14.9)
	Gender – male (%)	53.6	56.0	42.1	62.7
	Monthly earnings – median decile	9th	7th	5th	4th
	Trust only a few people (% agree or strongly agree)	82.0	76.4	71.0	50.6
	People take advantage of him/her (% agree or strongly agree)	87.1	84.8	84.3	63.5
	Parent education - mode	High school	High school	Postsecondary	Postsecondary
	Ever had uncompleted education (%)	34.4	32.6	32.8	25.8
	Age leaving uncompleted education – mean (SD)	22.0 (7.8)	24.3 (7.9)	30.1 (10.7)	‡
	Wanted training last year but did not pursue (%)	35.3	31.7	40.8	61.3
	Reason for not pursuing				
	Too expensive	25.0	33.1	19.4!	6.5!
	Childcare / family	21.1	14.4	16.1!	17.4!
	Unexpected event	13.2	10.1	12.9!	0!
	Too busy working	10.5	12.9	35.5!	50.0!
	Distance education participation (%)	5.1	10.7	22.4	21.3
	Basic skills participation (%)	13.7	14.9	‡	‡
	HSE participation (%)	15.5	12.7	‡	‡

Note .[a] Maintaining numeracy group had sufficient unweighted sample size only in the at-home sample. ! interpret with caution – unweighted cell size is below 62. ‡ reporting standards not met because of low unweighted cell size. *Source:* U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

In the *low* and *minimal* numeracy groups, as shown in Figure 2, numeracy skill use at work was reported most frequently as never occurring. In the *high* numeracy group, use of all individual numeracy skills at work was reported most frequently as daily, except for preparing charts, graphs, and tables (mode was less than monthly) and using advanced math or statistics (mode was never). For numeracy skill use at home (see Figure 3), the mode was never for *low*, *minimal*, and *maintaining* numeracy groups in using fractions, decimals, and percentages, in preparing

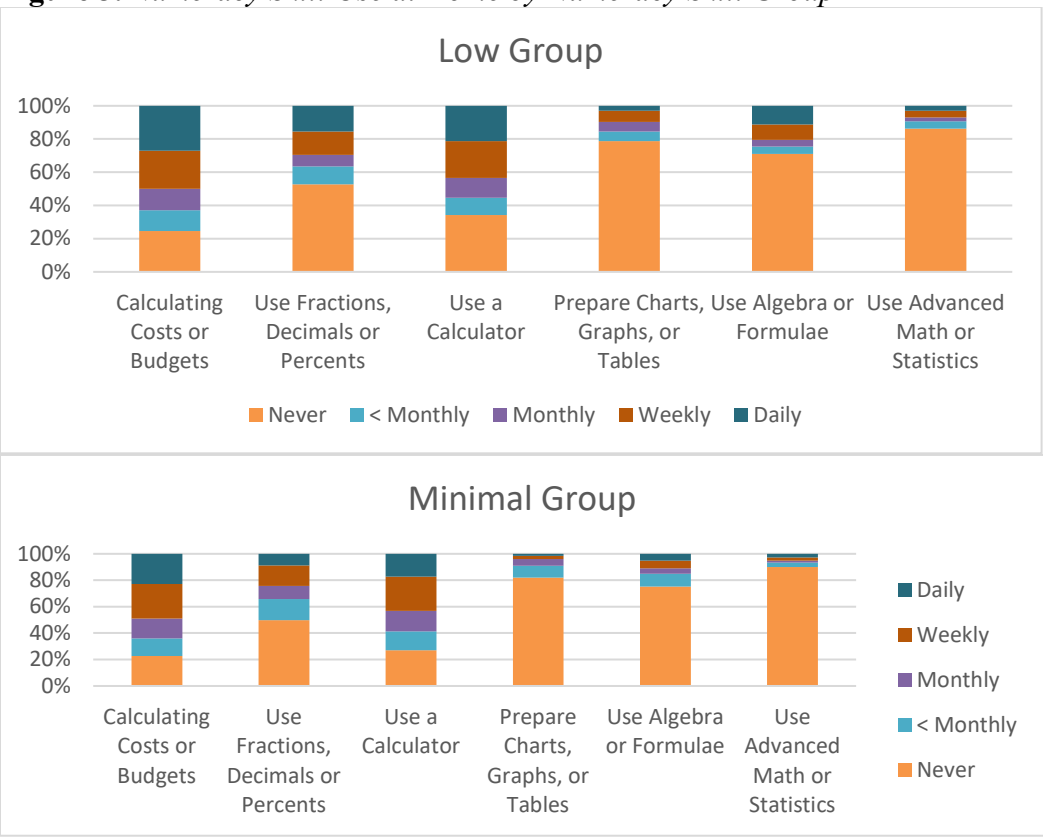
charts graphs, and tables, in using algebra and formulae, and in using advanced math or statistics. These three groups varied in their at-home frequency of use of calculating costs and budgets and in using a calculator. The *low* numeracy group's calculating costs and budgets was reported most often as daily, and as weekly in the other three groups. The *low and minimal* numeracy groups most frequently reported never using a calculator and the other two groups doing so weekly. At home, the *high* numeracy group reported a modal weekly use of calculating costs and budgets, using fractions, decimals, and percentages, using a calculator, and using algebra and formulae. The mode for the *high* numeracy group at home was never for preparing charts, graphs, and tables and in using advanced math or statistics.

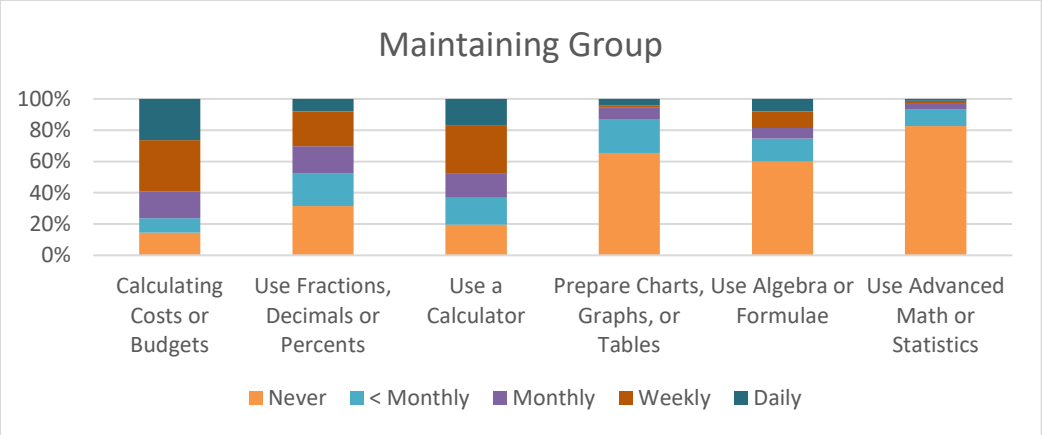
Figure 2. *Numeracy Skill Use at Work by Numeracy Skill Group*

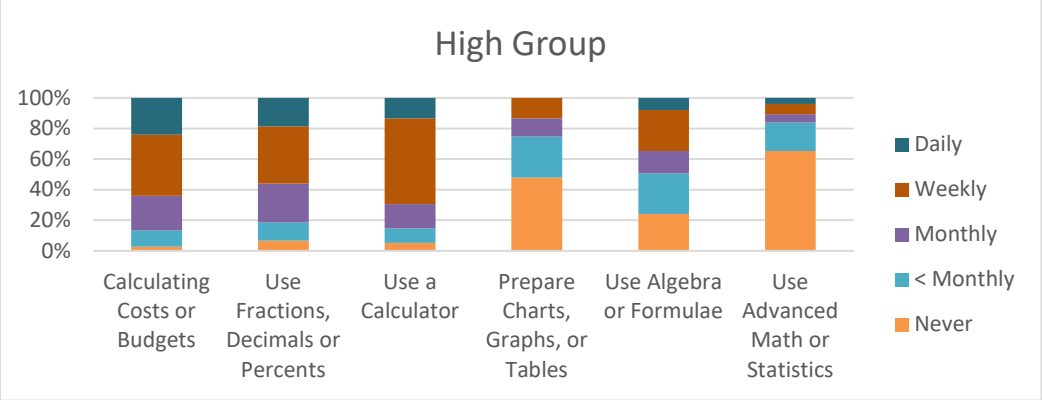


Source: U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

Figure 3. *Numeracy Skill Use at Home by Numeracy Skill Group*







Source: U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

Digital literacy skill use. Three groups describing digital literacy skill use of employed adults were also identified: *minimal* digital literacy (high school attainment and below level 1 PSTRE skills), *expanding* digital literacy (high school attainment and level 1 or higher PSTRE skills), and *high* digital literacy (postsecondary attainment and level 1 or higher PSTRE skills). Similar descriptors were employed for three groups of adults with LD in identifying digital literacy use at home: *minimal* digital literacy (high school attainment and below level 1 PSTRE skills), *expanding* digital literacy (high school attainment and level 1 or higher PSTRE skills), and *high* digital literacy (postsecondary attainment and level 1 or higher PSTRE skills). A fourth group was added to represent at-home digital literacy use, *low* digital literacy (less than high school attainment and level 1 or higher PSTRE skills). Characteristics of adults with LD by digital literacy group are displayed in Table 9. For employed adults with LD, higher digital literacy skills and skill use tended to be associated with higher monthly earnings, higher parental education attainment, increased distance education participation, and more computer use requiring moderate skills. At home, higher digital literacy skills were associated with increased monthly earnings, more participation in distance education, increased social trust, and a greater desire for pursuing more training yet not doing so.

Table 9
Characteristics of Adults with LD by Digital Literacy Group

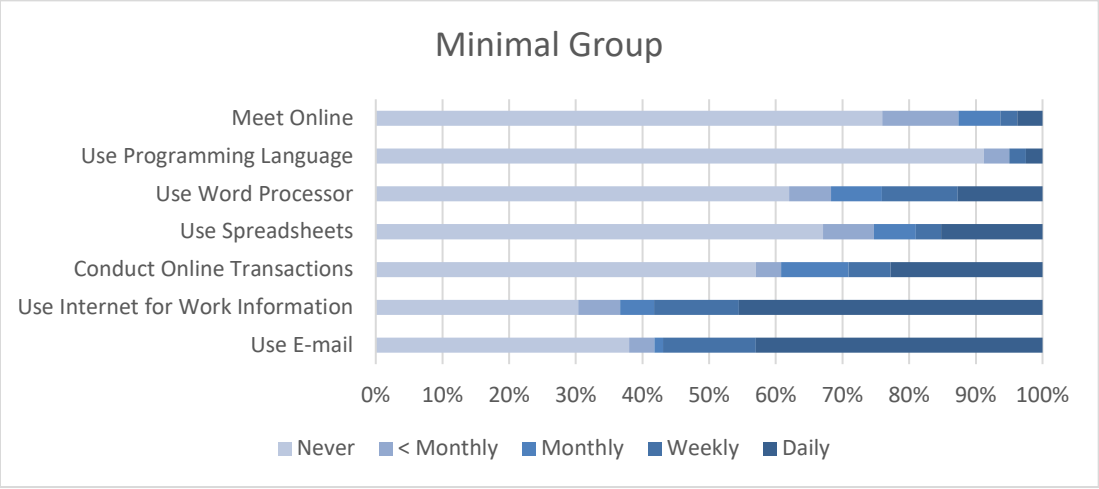
Location	Characteristic	Low Digital Literacy[a]	Minimal Digital Literacy	Expanding Digital Literacy	High Digital Literacy
At Work	*n*	‡	137	120	127
	Age – mean years (*SD*)	‡	33.1 (11.5)	31.6 (10.6)	37.8 (12.7)
	Gender – male (%)	‡	61.3	51.7	54.3
	Monthly earnings – median decile	‡	7th	7th	5th
	Parent education - mode	‡	High School and Post-secondary	Post-secondary	Post-secondary
	Uncompleted education (%)	‡	33.3	62.6	22.7
	Age leaving uncompleted education – mean (SD)	‡	24.5 (6.7)!	22.9 (4.5)!	‡
	Distance education participation (%)	‡	13.1	21.7	29.1
	Basic skills participation (%)	‡	13.3!	7.5!	‡
	HSE participation (%)	‡	10.0!	0!	‡
	Weekly hours worked - mean (SD)	‡	36.9 (14.2)	32.2 (15.5)	37.3 (12.7)
	Not challenged at work (%)	‡	90.5	97.5	90.6
	Need more training (%)	‡	28.7	10.0	23.6
	Computer use at work is straightforward (%)	‡	70.9	47.3	28.1
	Computer use at work is moderate (%)	‡	25.3	45.1	59.6
At Home	*n*	60!	90	220	160
	Age – mean years (*SD*)	20.4 (7.5)!	34.7 (13.8)	30.6 (11.8)	39.2 (14.1)
	Gender – male (%)	52.6	62.4	52.7	54.3
	Monthly earnings – median decile	‡	7th!	7th!	5th
	Trust only a few people (% agree or strongly agree)	75.5	81.7	71.9	54.9
	People take advantage of him/her (% agree or strongly agree)	82.5	86.0	81.1	68.7
	Parent education - mode	Post-secondary	High School	Post-secondary	Post-secondary
	Ever had uncompleted education (%)	‡	22.6	54.2	25.6
	Age leaving uncompleted education – mean (SD)	‡	‡	24.2 (6.8)	26.5 (8.2)!
	Wanted training last year but did not pursue (%)	‡	29.0	45.3	53.7
	Reason for not pursuing	‡	‡		

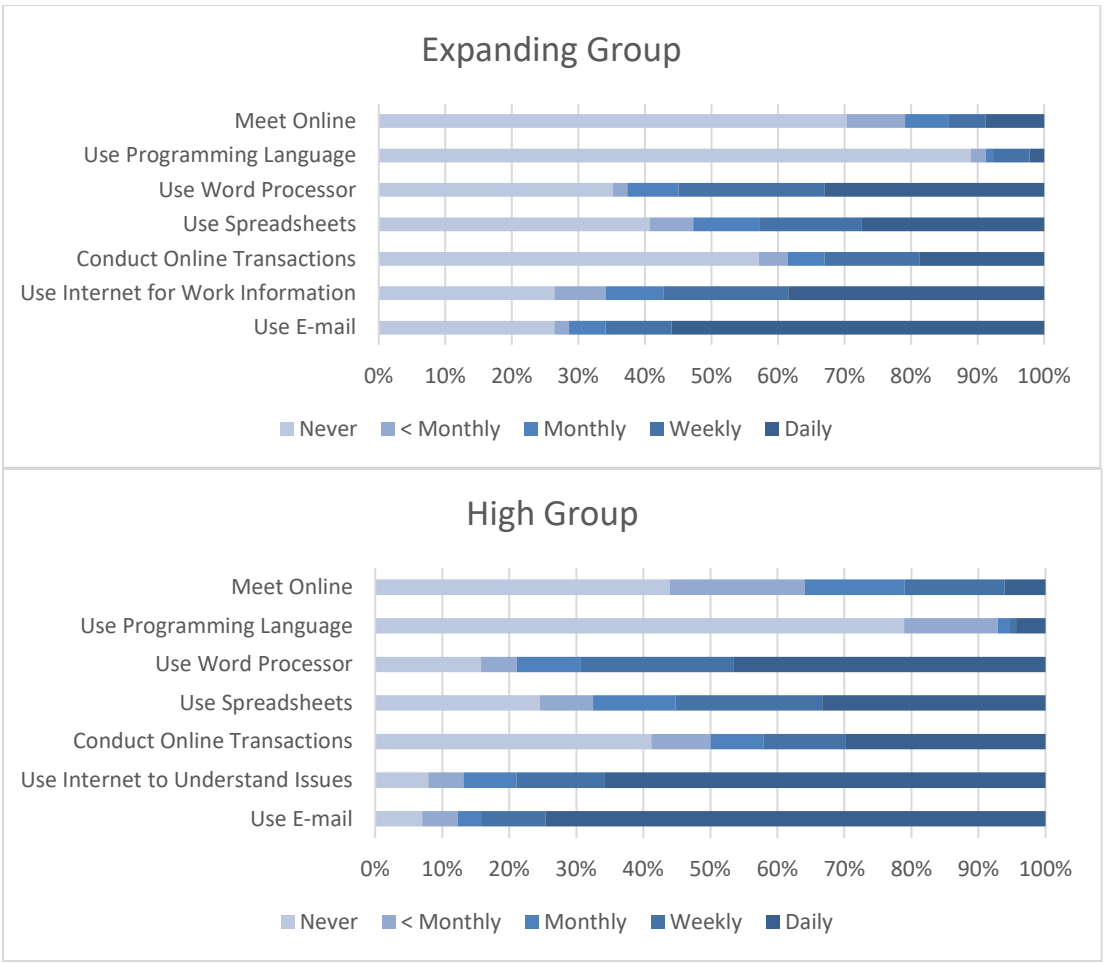
Location	Characteristic	Low Digital Literacy[a]	Minimal Digital Literacy	Expanding Digital Literacy	High Digital Literacy
	Too expensive			32.7	11.4
	Childcare / family			9.9	15.9
	Unexpected event			5.0	1.1
	Too busy working			17.8	43.2
	Distance education participation (%)	‡	9.7	17.9	26.2
	Basic skills participation (%)	28.1	‡	13.5	‡
	HSE participation (%)	12.3	‡	2.8	‡

Note. [a] Low digital literacy group had sufficient unweighted sample size only in the at-home sample. ! interpret with caution – unweighted cell size is below 62. ‡ reporting standards not met because of low unweighted cell size.
Source: U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

All three digital literacy groups at work most frequently reported daily use of e-mail and the internet for work issues, as displayed in Figure 4. The mode for all other digital literacy skill use statements at work for the *minimal* and *emerging* digital literacy groups was never. In the *high* digital literacy group, respondents most frequently reported using a spreadsheet and word processor daily at work, yet the mode for conducting transactions online, using programming language, and participating in online groups was never. At home, all four digital literacy groups reported daily use of e-mail and going online to understand issues (see Figure 5). All four groups also reported never as a mode for using spreadsheets, using programming language, and participating in online meetings at home. The *low*, *minimal*, and *high* groups most frequently reported never conducting transactions online at home, yet the *expanding* group did so weekly as a mode. The *low* and *expanding* groups tended to use a word processor at home weekly, yet the mode for the *minimal* and *high* groups on using a word processor at home was never.

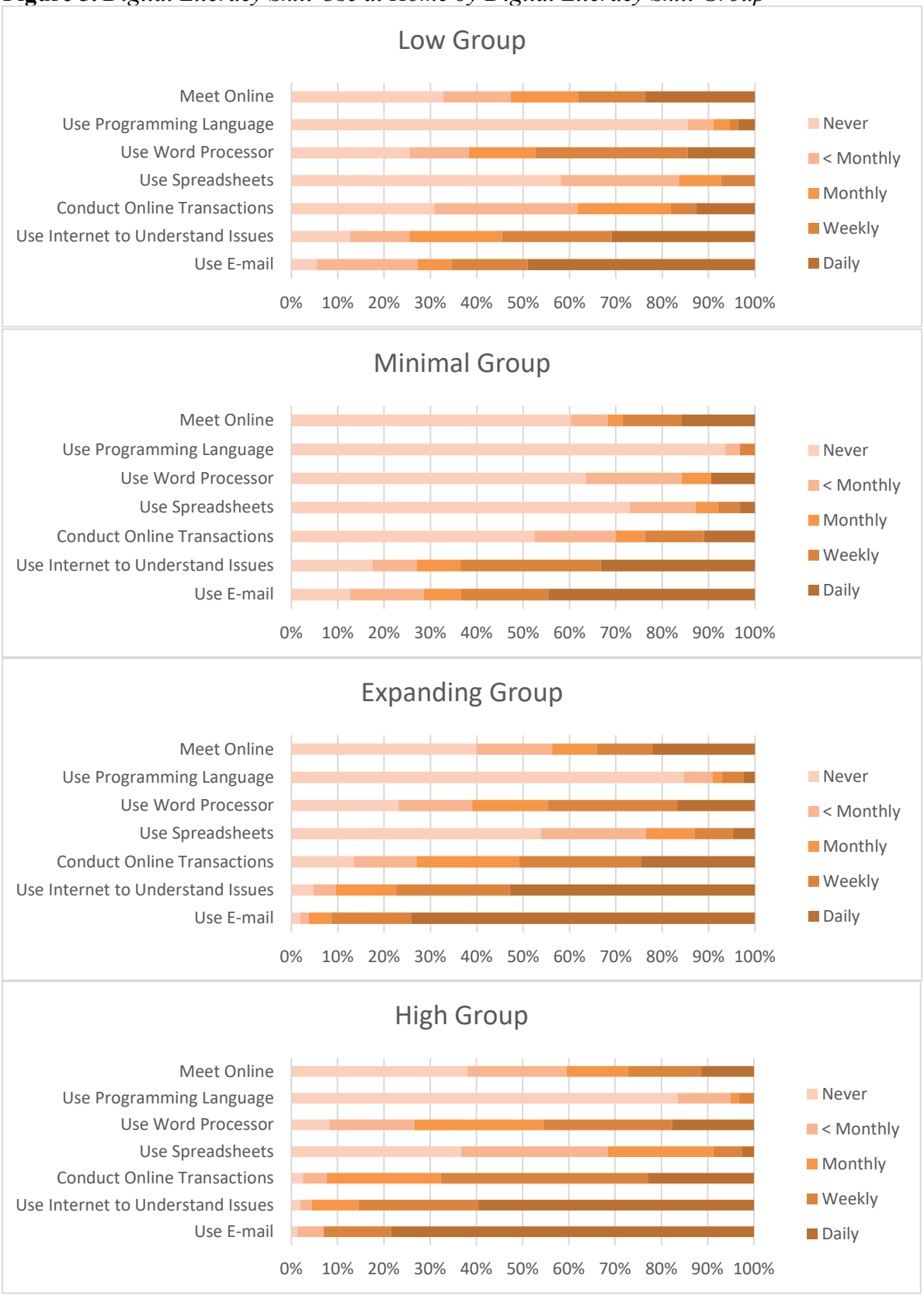
Figure 4. *Digital Literacy Skill Use at Work by Digital Literacy Skill Group*





Source: U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

Figure 5. *Digital Literacy Skill Use at Home by Digital Literacy Skill Group*



Source: U.S. Department of Education, National Center for Education Statistics, U.S. Program for the International Assessment of Adult Competencies (PIAAC), 2012/2014/2017.

Discussion

A summary of key findings is provided to frame the discussion that follows. Although both adults with LD and in the general population have numeracy skills averaging at Level 2 and digital literacy skills at Level 1, adults with LD have moderately lower mean numeracy scores and slightly lower mean digital literacy scores than their counterparts in the general population. Adults with LD who are employed and have no health issues tend to have higher average skills in numeracy and digital literacy than adults with LD overall, yet adults with LD who have health concerns and other disabling conditions tend to score substantially lower. These findings are a concern with respect to health-related outcomes (Yamashita et al., 2018; Yamashita & Kunkel, 2015), particularly since just under half of adults with LD are employed, and the incidence of coexisting health or disabling conditions and permanent disability is high.

A critical health-related finding is that adults with LD have twice the incidence of fair/poor health, vision difficulties, and hearing difficulties as adults without LD. Adults with diagnosed LD and health-related concerns may already be highly aware of how overall health, vision, and hearing interacts with their learning and, if they have disclosed their disability, have accommodations in place in the classroom or workplace. If not, they need access to health screenings and supports, such as hearing aids or assistive technology, that can enable their equitable participation in learning and employment (if applicable). Resources to support equitable technology access from websites such as https://www.w3.org/WAI or https://webaim.org/ may also be useful. Use of color overlays, changes in types of lighting, printing on colored paper, and other low-cost measures may benefit some adults with LD and with vision difficulties as they learn (Patterson, 2019).

Adult education programs may help adults with LD identify unrecognized health-related challenges by routinely screening new learners and referring them to healthcare or psychological service providers to learn more about coexisting conditions (Patterson, 2019). Accessing supports, however, often implies that they have been able to cover the costs of a psychoeducational diagnosis and have sufficient health insurance (Housel, 2020). For adults with LD seeking employment, an important resource is vocational rehabilitation (VR) services (Patterson, 2019). If they face barriers to employment, including needs for further training to become employed, VR services are available to qualifying adults with LD from local or state agencies. VR counselors can access further diagnostic services and identify accommodations during training and on the job. In addition to making referrals, adult education programs need to meet with VR staff periodically to share resources and answer mutual questions.

Additionally, development of numeracy and digital literacy skills and expansion of access to technology can aid adults with LD in seeking, evaluating, and using online health-related information (Feinberg et al., 2016). Developing these skills may require access to and participation in adult and/or postsecondary education, particularly in programs geared toward health-related needs. Furthermore, if health promotion and education interventions and materials are developed at basic reading levels and offered online, adults can gain access to the information digitally (Feinberg et al., 2016).

With respect to use of skills, employed adults, whether with LD or in the general population, have similar levels of numeracy skill use. Employed adults in the general population have slightly higher average use of digital literacy than employed adults with LD. Employment appears to provide a slight advantage in use of numeracy skills at home for adults with LD, in comparison to adults with LD who are out of the labor force. Adults with LD who are out of the labor force report using digital literacy skills at home slightly less often than employed adults with LD do. Furthermore, regression models indicate that use of skills at home adds to variance explained in both numeracy and digital literacy skills; use of digital literacy skills at work does so for digital literacy skills as well. These findings suggest that using numeracy skills and digital literacy skills matter in gaining – or keeping – the skills themselves.

Both higher numeracy skills and digital literacy skills and skill use of adults with LD at home or at work tend to be associated with higher monthly earnings, more parental education, and with increased distance education participation. For employed adults with LD, higher numeracy skills tend to be associated with increased age and more hours of weekly work, and higher digital literacy skills with more computer use requiring moderate skills. An average monthly use of numeracy skills and weekly use of digital literacy skills among employed adults with LD leaves plenty of opportunity for adults to gain – and use – skills that might be able to secure them more hours of work, higher earnings, or more distance learning. At home, higher numeracy skills of adults with LD tend to be related to lower incidence of uncompleted education. Higher digital literacy skills tend to be related to a greater desire for pursuing more training yet not doing so. Higher numeracy and digital literacy skills both tend to be associated with increased social trust. Use of both skill domains no more than monthly points to wide-open opportunities to strengthen these skills at home, with potential benefits to their unmet goals for more learning and to social trust.

Use of numeracy and digital literacy skills is critical to gaining and maintaining those skills. Practice engagement theory is supported in three of this paper's models. Reder and colleagues (2020) suggest that basic skills programs can foster increases in practice engagement – that is, use of skills – that benefit skill levels in the long term. They note that formal and non-formal instructional programs centering on improving skill use "may point in a promising direction for innovation in adult education and lifelong learning" (p. 284). This point has policy implications as well. Adult and postsecondary education policies that support adults with LD to engage in more numeracy and digital literacy activities can simultaneously encourage not only the association with skill growth but also with lifelong learning and access to postsecondary education and career and technical opportunities (Reder et al., 2020). Since discrete groups of adults with LD who participated in postsecondary education (*high numeracy and digital literacy* groups) appear to have much greater use of numeracy and digital literacy skills than those completing high school or less, this encouragement is critical to the association with skill growth. By referencing data findings on numeracy and digital literacy skills and skills use from this paper, education or training program planners have accurate, up-to-date information from which to plan numeracy or digital literacy course development.

Another important finding from the groups analyses is that adults with LD appear to have a desire for learning, yet completion may be a challenge. A sizable percentage of adults with LD

report participating in basic skills instruction, with a range of 11% to 28%, even in groups of adults that report finishing high school. At home, a wide range of adults with LD, from 29% to 61% of discrete groups, reported wanting to pursue education or training in the past year but did not pursue it – a disheartening implication noted in previous work (Patterson, 2019). Major reasons that adults report include cost and, for adults in high numeracy and digital literacy groups, being too busy at work. With generally low employment and low monthly earnings, except in the *high* numeracy and digital literacy groups, it is not surprising that many adults with LD indicate not being able to afford further education or training. In the groups identified in this paper, the rates of uncompleted education among adults with LD are high, ranging from 22% to 63% per group.

Knowing relationships of assessed skills with skill use for this population has the potential to inform practice and identify strategies adult and postsecondary educators – and the community service partners who work with them to refer and support adults with LD (Housel et al., 2020) – can implement to support adult program completion. Even though data employed in this paper pre-date the 2020 pandemic, these relationships are highly relevant in the primarily online environment for learning occurring during the pandemic. Policymakers need to consider enacting policies that can support adults with LD to find resources to attend and complete education or training that so many clearly want. In addition to making policy to offer financial resources, such as grants and loans for tuition costs, policies need to ensure that adequate resources are available to support to adults in meeting needs associated with health and disabling conditions. Adults with overlapping disability and health challenges need this differentiated support to learn how to balance their needs as individuals and as potential adult learners (Budd et al., 2016). Entering an education or training program should not add to their burdens or cause psychological stress that negatively affects their health (Madaus & Shaw, 2011).

The frustrated desire for learning has implications for basic skills, as well as postsecondary, recruitment and instruction. How then, to recruit and engage adults with LD? Encouraging adults with LD to see themselves as numerate or digitally literate may not only empower them to use the skills but to continue to seek skills. If adults see a basic skills program, postsecondary coursework, or a training program as offering them the resources they are looking for to start or resume a career or gain knowledge for everyday life, it becomes much more appealing than entering a place where they may feel stigmatized or unwelcome because of their low numeracy or digital literacy skills. How a program brands itself and puts its welcoming message in recruitment materials for adults with LD is pivotal to their decision to enter – and likely to their retention.

Once an adult with LD has been recruited to a basic skills program, for example, adult educators need to think through their own assumptions about what adults may recognize, understand, and be able to do (Housel et al., 2020; Sellers & Byrne, 2015) in either numeracy or digital literacy. They may need to check in with adult learners with LD on their skill levels and behaviors in either domain. In numeracy, for example, Curry (2017) recommends asking adults questions about their numeracy skill use, "to determine the types of numerate behaviors they already engage in" (p. 4). Adult educators could encourage adults with LD to discuss how they employ their numeracy skills, perhaps during program orientations or at the start of math instruction, without singling them out as having LD. Adult learners could interview each other about how

they use math – even using PIAAC numeracy questions from Table 1 – or how they addressed a situation where math was needed. Curry's (2017) guide provides instructional implications (pp. 7-10), instructional planning examples (pp. 11-23), and examples of contextual and complexity factors (pp. 25-28).

In digital literacy, Vanek (2017) encourages explicit instruction on problem-solving processes. On p. 14 Vanek offers a step-by-step table for teaching the problem-solving process in technology environments. She gives examples designed to help adult learners map problems to solve a technology challenge (p. 16). Her third section covers how to teach problem solving, including examples with different levels of complexity, and she offers guidance on creating learning activities (pp. 30-34). Both Curry's and Vanek's guides (2017) offer ways for adult educators to check assumptions, ask adults about their skills and skill use, plan approaches to instruction, and consider examples they could apply in their own classroom or tutoring environment.

Increasing the future representation of adults with LD in skilled occupations is also important (Housel et al., 2020). Remaining in long-term, low-paying positions or leaving the workforce altogether (unless doing so voluntarily), as evidenced in the large proportion of adults with LD who are out of the workforce or on permanent disability, leads to substantial loss of human capital, not only in the workforce but also in the larger community (Patterson, 2019). This paper's examination of discrete groups in terms of assessed skills and skill use at home or at work further explains the circumstances adults face (Patterson, 2020) and yields implications for transitional planning. Human resources staff in workplaces with diversity programs can access the information on numeracy and digital literacy skills to help them plan for numeracy and digital literacy training needs of employees with LD. Seeing the many ways in which the skill use of adults with LD overlap with adults in the general population may even encourage further diverse hiring practices to engage adults with LD in the workforce. To the extent human resources staff can support the training needs of adults with LD, the returns to the workplace appear promising.

Limitations of the Study and Planning for Future Research

As in previous PIAAC papers, some limitations occur. First, the PIAAC indicator for an LD diagnosis is self-reported and does not specify the type of LD. In this paper, significant differences in reported LD identification occurred for males (χ^2 48.5, p <.001, odds ratio 1.55) and younger adults (t 321.9, p <.001, d 0.32), which appears to reflect traditionally strong identification of males with LD as well as psychoeducational testing emphases since 1976 occurring in U.S. schools (Cortiella & Horowitz, 2014). Differences in self-reported LD were not meaningful by ethnicity, income, or U.S. region, however.

Also, although several informative indicators are in PIAAC, limited information on coexisting health and disabling conditions was collected. For example, even with a moderate rate of coexisting reading and math disabilities (Willcutt et al., 2013), knowing that an adult was diagnosed with dyscalculia specifically, in contrast with LD in general or with a reading disability, may be even more informative to understanding differences in numeracy skills. Investigating literacy was beyond the scope of this paper; future researchers may wish to consider the relationships of LD with assessed literacy skills and use of literacy skills – and how

those relationships interact with the findings presented here. Another limitation is that PSTRE scores are legitimately missing for adults who could not take this assessment. This limitation means that further analysis of data on adults with LD who were missing these scores would add important information on groups that were beyond the scope of this paper to study.

Even as many important indicators of demographics and backgrounds are available to describe this population, the paper does not fully represent the qualitative experiences of individual adults with LD, such as why more than half are not employed or the circumstances under which they are not completing education or training that they say they want. Nor does PIAAC explain the details of their skill use at home and at work. Future qualitative research with adults having LD could fill in the picture and potentially lead to further implications for practice and policy.

Another finding worth further investigation is that higher numeracy skills and digital literacy skills of adults with LD at home or at work tend to be associated with increased distance education participation. Researchers may wish to investigate this connection in future PIAAC datasets, particularly since distance education became the primary way any education or training was delivered during the pandemic and is likely to be a major delivery method for the foreseeable future.

References

Bergson-Shilcock, A. (2020). *The new landscape of digital literacy: How workers' uneven digital skills affect economic mobility and business competitiveness, and what policymakers can do about it.* National Skills Coalition. https://files.eric.ed.gov/fulltext/ED607391.pdf

Budd, J., Fichten, C., Jorgensen, M., Havel, A., & Flanagan, T. (2016). Postsecondary students with specific learning disabilities and with attention deficit hyperactivity disorder should not be considered as a unified group for research or practice. *Journal of Education and Training Studies*, *4*(4), 206–216. https://doi.org/10.11114/jets.v4i4.1255

Capsada-Munsech, Q. (2020). Overeducation, skills and social background: The influence of parental education on overeducation in Spain. *Compare, 50*(2), 216-236. https://www.tandfonline.com/doi/abs/10.1080/03057925.2019.1579085

Coben, D., & Alkema, A. (2017). The case for measuring adults' numeracy practices. *Journal of Research and Practice for Adult Literacy, Secondary, and Basic Education, 6*(1), 20-32. https://researchcommons.waikato.ac.nz/bitstream/handle/10289/11426/COABE%202017%20The%20Case%20for%20Measuring%20Adults%27%20Numeracy%20Practices.pdf?sequence=19&isAllowed=y

Coben, D., Miller-Reilly, B., Satherley, P., & Earle, D. (2016). Making the most of PIAAC: Preliminary investigation of adults' numeracy practices through secondary analysis of the PIAAC dataset. *Adults Learning Mathematics: An International Journal, 11*(2), 27-40. https://files.eric.ed.gov/fulltext/EJ1123375.pdf

Cortiella, C., & Horowitz, S. H. (2014). *The state of learning disabilities: Facts, trends and emerging issues*. National Center for Learning Disabilities. https://www.ncld.org/wp-content/uploads/2014/11/2014-State-of-LD.pdf

Cummins, P. A., Yamashita, T., & Arbogast, A. (2018). *An examination of PIAAC Data for unemployed adults aged 45–74.* https://piaac.squarespace.com/s/Cummins-Yamashita-Arbogast_2018.pdf

Curry, D. (2017). *Using the PIAAC Numeracy Framework to guide instruction: An introduction for adult educators*. https://static1.squarespace.com/static/51bb74b8e4b0139570ddf020/t/58891aa81b631b5929d4c05f/1485380267014/Numeracy_Guide_Curry_2017.pdf

Feinberg, I., Frijters, J., Johnson-Lawrence, V., Greenberg, D., Nightingale, E., & Moodie, C. (2016). Examining associations between health information seeking behavior and adult education status in the U.S.: An analysis of the 2012 PIAAC data. *PLoS ONE 11*(2): e0148751. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0148751

Gal, I., Grotlüschen, A., Tout, D., & Kaiser, G. (2020). Numeracy, adult education, and 'vulnerable' learners: A critical review of a neglected field. *ZDM Mathematics Education, 52,* 377-394. https://doi.org/10.1007/s11858-020-01155-9

Ginsburg, L. (2017). What's an adult numeracy teacher to teach? Negotiating the complexity of adult numeracy instruction. *Journal of Research and Practice for Adult Literacy, Secondary, and Basic Education, 6*(1), 57-61. https://coabe.org/wp-content/uploads/2019/09/2017SpringCOABEJournal.pdf

Grotlüschen, A., Mallows, D., Reder, S., & Sabatini, J. (2016). Adults with Low Proficiency in Literacy or Numeracy. *OECD Education Working Papers, No. 131*. Paris, France: OECD Publishing. https://doi.org/10.1787/5jm0v44bnmnx-en

Hogan, J., Thornton, N., Diaz-Hoffmann, L., Mohadjer, L., Krenzke, T., Li, J., & VanDeKerckhove, W. (2016). *Program for the International Assessment of Adult Competencies (PIAAC) 2012 and 2014: U.S. Main Study and National Supplement Technical Report (NCES 2016-036)*. U.S. Department of Education: National Center for Education Statistics. https://nces.ed.gov/pubs2016/2016036.pdf

Hollinger, J., & Larwin, K. (2019). Numeracy and adults' learning readiness and commitment: Results from a large national random sample of participants. *International Journal of Teaching and Learning in Higher Education, 31*(3), 437-451. https://files.eric.ed.gov/fulltext/EJ1245087.pdf

Housel, D. A. (2020). When co-occurring factors impact adult learners: Suggestions for instruction, preservice training, and professional development. *Adult Learning, 31*(1), 6-16. https://journals.sagepub.com/doi/full/10.1177/1045159519849910

Jonas, N. (2018). Numeracy practices and numeracy skills among adults, *OECD Education Working Papers, No. 177*. Paris, France: OECD Publishing. https://doi.org/10.1787/8f19fc9f-en

Madaus, J., & Shaw, S. (2011) (Revised). *College as a realistic option for students with learning disabilities*. Council for Learning Disabilities. https://council-for-learning-disabilities.org/wp-content/uploads/2017/07/College_OptionforSLD.pdf

McKenna, G. S. (2010). *Can learning disabilities explain low literacy performance?* Canada Human Resources and Skills Development Canada. https://files.eric.ed.gov/fulltext/ED517061.pdf

Mellard, D. F., & Patterson, M. B. (2008). Contrasting adult literacy learners with and without specific learning disabilities. *Remedial and Special Education*, *29*(3), 133–144. https://doi.org/10.1177/0741932508315053

Millar, R. J., Sahoo, S., Yamashita, T., & Cummins, P. A. (2020). Literacy skills, language use, and online health information seeking among Hispanic adults in the United States. *Patient Education and Counseling*, https://doi.org/10.1016/j.pec.2020.02.030

National Research Council. (2012). *Improving adult literacy: Options for practice and research*. National Academy of Sciences. https://www.nap.edu/catalog/13242/improving-adult-literacy-instruction-options-for-practice-and-research

Nwakasi, C. C., Cummins, P. A., Mehri, N., Zhang, J., & Yamashita, T. (October 2019). Problem solving in technology-rich environments, adult education and training, and income: An international comparison using PIAAC data. St. Louis, MO: Commission for International Adult Education Conference. https://files.eric.ed.gov/fulltext/ED600452.pdf

OECD. (2013). *Technical report of the Survey of Adult Skills (PIAAC): Prepublication Copy*. Paris, France: OECD Publishing. https://www.oecd.org/skills/piaac/_Technical%20Report_17OCT13.pdf

Patterson, M. B. (2014). Post-GED-credential college prospects for adults with special needs. *Journal of Research and Practice for Adult Literacy, Secondary, and Basic Education*, *22*(3), 22–35. https://coabe.org/wp-content/uploads/2019/09/COABEJournalFall2014.pdf

Patterson, M. B. (2019). Adults with low skills and learning disabilities. In D. Perin (Ed.), *Wiley Handbook of Adult Literacy* (pp. 336-360). https://doi.org/10.1002/9781119261407.ch16\

Patterson, M. B. (2020). PIAAC numeracy skills and home use among adult English learners. *Adult Literacy Education, 2*(1), 22-40. https://files.eric.ed.gov/fulltext/EJ1248996.pdf

Patterson, M. B., & Paulson, U. (2016). Adult transitions to learning in the USA: What do PIAAC results tell us? *Journal of Research and Practice for Adult Literacy, Secondary and Basic Education, 5*(1), 5-27. https://eric.ed.gov/?id=EJ1098806

Payne, N. A. (2010). *Adults who have learning disabilities: Transition from GED to postsecondary activities* [Doctoral dissertation, Capella University].

PIAAC Expert Group on Problem Solving in Technology-Rich Environments. (2009). *PIAAC Problem Solving in Technology-Rich Environments: A conceptual framework*. Organisation for Economic Co-operation and Development. (OECD Education Working Paper No. 36). https://www.oecd-ilibrary.org/docserver/220262483674.pdf?expires=1626466695&id=id&accname=guest&checksum=C56B7685963DFE747DDCDC84BEAA0215

Prins, E., & Monnat, S. (2015). Examining associations between self-rated health and proficiency in literacy and numeracy among immigrants and US-born adults: Evidence from the Program for the International Assessment of Adult Competencies (PIAAC). *Plos One, 10*(7), 25. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0130257

Rampey, B. D., Finnegan, R., Goodman, M., Mohadjer, L., Krenzke, T., Hogan, J., and Provasnik, S. (2016). *Skills of U.S. unemployed, young, and older adults in sharper focus: Results from the Program for the International Assessment of Adult Competencies (PIAAC) 2012/2014: First look* (NCES 2016-039rev). U.S. Department of Education: National Center for Education Statistics. https://nces.ed.gov/pubs2016/2016039.pdf

Reder, S. (2019). Numeracy imprisoned: Skills and practices of incarcerated adults in the United States. *ZDM Mathematics Education.* Advance online publication. https://doi.org/10.1007/s1185 8-019-01094-0.

Reder, S., Gauly, B., & Lechner, C. (2020). Practice makes perfect: Practice engagement theory and the development of adult literacy and numeracy proficiency. *International Review of Education, 66*(2), 267-288. https://doi.org/10.1007/s11159-020-09830-5

Reynolds, S. L., Johnson, J. D., & Salzman, J. A. (2012). Screening for learning disabilities in adult basic education students. *Journal of Postsecondary Education and Disability*, *25*(2), 179–195. https://files.eric.ed.gov/fulltext/EJ994285.pdf

Richardson, J. T. (2014). Academic attainment of students with disabilities in distance education. *Journal of Postsecondary Education and Disability*, *27*(3), 291–305. https://files.eric.ed.gov/fulltext/EJ1048782.pdf

Roffman, A. (2000). *Meeting the challenge of learning disabilities in adulthood*. Paul H Brookes Publishing.

Sellers, D, & Byrne, T. (2015). Numeracy into action: Putting numeracy research into practice. *Irish Journal of Adult and Community Education*, 112-120. https://files.eric.ed.gov/fulltext/EJ1077740.pdf

Smith, M. C., Rose, A. D., Smith, T. J., & Ross-Gordon, J. M. (2015*). Adults' readiness to learn and skill acquisition and use: An analysis of PIAAC*. Adult Education Research Conference. https://newprairiepress.org/cgi/viewcontent.cgi?article=1147&context=aerc

Takemoto, C. (2016). *Supporting successful reentry for people with disabilities: A brief guide to issues and resources*. U.S Department of Education, Office of Career, Technical, and Adult Education. https://learner.lincs.ed.gov/reentryed/files/tools_pdf/Disability_BriefGuidetoIssuesandResources.pdf

Takemoto, C. (2017). *Supporting successful reentry for people with disabilities: Disability-specific supports.* [Revised edition]. U.S Department of Education, Office of Career, Technical, and Adult Education. https://learner.lincs.ed.gov/reentryed/files/tools_pdf/Disability_Specific_Supports_revised092917.pdf

Vanek, J. (2017). *Using the PIAAC Framework for Problem Solving in Technology-Rich Environments to guide instruction: An introduction for adult educators*. https://static1.squarespace.com/static/51bb74b8e4b0139570ddf020/t/589a3d3c1e5b6cd7b42cddcb/1486503229769/PSTRE_Guide_Vanek_2017.pdf

Whetzel, M. (2016). Executive function deficits, higher level employees, and accommodations. *Job Accommodation Network E-News, 14*(1). https://askjan.org/articles/Executive-Function-Deficits-Higher-Level-Employees-and-Accommodations.cfm

Willcutt, E. G., Petrill, S. A., Wu, S., Boada, R., DeFries, J. C., Olson, R. K., & Pennington, B. F. (2013). Comorbidity between reading disability and math disability: Concurrent psychopathology, functional impairment, and neuropsychological functioning. *Journal of learning disabilities*, *46*(6), 500-516. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3749272/

Yamashita, T., Bardo, A. R., & Liu, D. (2018). *Numeracy skills, health information-seeking, and preventative health behaviors among middle and older aged adults in the U.S.* https://static1.squarespace.com/static/51bb74b8e4b0139570ddf020/t/5b50a5b80e2e72f3e4d63ae5/1532011961211/Yamashita_Bardo_Liu_Health_Report2018_Final.pdf

Yamashita, T., & Kunkel, S. R. (2015). An international comparison of the association among literacy, education, and health across the United States, Canada, Switzerland, Italy, Norway, and Bermuda: Implications for health disparities. *Journal of Health Communication*, *20*(4), 406-415. https://www.tandfonline.com/doi/abs/10.1080/10810730.2014.977469

[i] Numeracy levels are below Level 1 (0-175), Level 1 (176-225), Level 2 (226-275), Level 3 (276-325), and Levels 4 / 5 (326-500), according to Rampey et al. (2016). In PSTRE, levels include below Level 1 (0-240), Level 1 (240-290), Level 2 (291-340), and Level 3 (341-500). At Numeracy Level 2, "Tasks tend to require the application of two or more steps or processes involving calculation with whole numbers and common decimals, percents and fractions; simple measurement and spatial representation; estimation; and [interpreting] relatively simple data and statistics in

texts, tables and graphs." At PSTRE Level 1, "Tasks typically require the use of widely available… technology applications, such as e-mail software or a web browser. There is little or no navigation required to access the information or commands required to solve the problem… tasks involve few steps and a minimal number of operators… Only simple forms of reasoning, such as assigning items to categories, are required; there is no need to contrast or integrate information."