http://doi.org/10.35847/MPatterson.7.1.4

Research Article

U.S. Adults in Foundational Education: Backgrounds and Skills of Learners with Low Numeracy Skills

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Abstract

Adults with low numeracy skills often start adult foundational education services or work with individual tutors. Using U.S. PIAAC 2012/2014/2017 data, this paper examines the characteristics, educational backgrounds, and numeracy proficiency of adult learners in adult foundational education, along with use of numeracy skills at home and how skills predict use. Despite challenges in employment, incomplete education, and a learning disabilities rate of nearly 15%, adult foundational education learners have an interest in learning strategies and computer experience and include a high percentage of English learners. Adult foundational education learner numeracy scores generally fall at Level 1, but positive links occur between numeracy skills and use, particularly in calculations and financial transactions. The paper offers resources for instructors to enhance learner numeracy.

Keywords: adult learners, numeracy, foundational education, practice engagement, PIAAC

Attention to numeracy has increased recently around the globe as society becomes number drenched (Prendergrast et al., 2023). Adult numeracy is of vital interest to societies and economies worldwide yet is also underresearched (Gal et al., 2020). Low adult numeracy is believed to be associated with unemployment and the need for social assistance (Oughton, 2018). As U.S. society increasingly relies on quantitative information (Cummins et al., 2018), investigating how numeracy skills—practices in everyday life involving mathematics activities (Hogan et al., 2016)— of learners in adult foundational education ("AFE learners") compare is important (Patterson, 2023).

Beyond economic and societal considerations, numeracy scholars argue for a view encompassing adults' numeracy practices and potential vulnerabilities, and their beliefs, attitudes, and personal goals. These goals may include learning numeracy skills toward a high school equivalency (HSE) credential, making family life easier, or even learning simply for fun (Oughton, 2018). To navigate daily life, help their children with schoolwork, and understand their changing health with age, adults need numeracy skills (Coben & Alkema, 2017; Ginsburg, 2017; Yamashita et al., 2018). Without these skills, adults may be vulnerable (Gal et al., 2020). Vulnerability with respect to adult numeracy may result from personal, societal, and systemic sources. Gal and colleagues (2020) ask a compelling question: what are the numeracy practices of vulnerable groups and how should such practices be considered when planning and implementing instruction? One vulnerable group is AFE learners with low numeracy skills.

Many U.S. adults have yet to gain numeracy skills. In the U.S. Programme for the International Assessment of Adult Competencies (PIAAC), scores average 257 (Level 2 in numeracy skills; Patterson, 2023). Nearly one in three U.S. adults has low assessed PIAAC numeracy skills, a rate of low skills exceeding that of other countries participating in PIAAC (Organization for Economic Cooperation and Development [OECD], 2016; Oughton, 2018). In almost all countries, a sizeable proportion of adults (22.7% on average) have poor numeracy skills (Level 1 or below;

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Tout et al., 2017). Having low numeracy skills is a particular challenge for young U.S.-born adults (Sands et al., 2018) or for immigrants learning English (Patterson, 2020; Saal et al., 2018). Sands and colleagues (2018) found that unemployed millennials not enrolled in education were at or below Level 1 in numeracy skills at nearly twice the rate (47%) as millennials overall (25%). Aggregate English learner (EL) findings include a mean PIAAC numeracy score of 208, much lower than the population average of 257 (Saal et al., 2018).

Adults with low numeracy skills may seek AFE services or individual tutors to gain needed skills, and recent trends indicate half of adults with the lowest numeracy skills gain these skills through programs. Evidence suggests, however, that less than 10% of eligible U.S. adults do so (Patterson, 2018), and even that small rate of participation is dwindling (Pickard, 2022). As fewer U.S. adults seek federally and state funded AFE services (Pickard, 2022), the 2020-2022 global pandemic has further challenged accessing services, and these shifts disproportionately affect AFE learners at the lowest skill levels (Belzer et al., 2020, 2022).

This paper posits that low numeracy is associated with unemployment, low income, low education attainment, disability/health factors, and low skill use. Employing the restricted-use 2012/2014/2017 PIAAC dataset, to understand AFE learners with low numeracy skills more deeply, this paper investigates the characteristics, education backgrounds, and numeracy skills of adults participating in basic skills, HSE, and English learning (EL) opportunities. AFE learners are an important subgroup of vulnerable adults. Post-pandemic evidence shows fewer adults seek AFE services, particularly at the lowest levels. By reviewing what we know about AFE learners with low numeracy and how they use numeracy skills, we can seek solutions to engage more adults in AFE. This paper examines how AFE learners use basic numeracy at home and predictive relationships between skills and skill use.

Literature Review

Adult Background Characteristics

Background characteristics of AFE learners with low numeracy skills include education attainment and income. These adults tend to leave high school early and to have substantial rates (22%) of not being in employment or education (Patterson, 2019). Although many adults with low numeracy skills report wanting more education (Bergson-Shillcock, 2017), a sizable proportion does not do so; one-fourth of U.S. adults with numeracy skills at or below Level 1 (28%) agreed they wanted to pursue training, the highest rate in PIAAC countries (Grotlüschen, 2018). Low numeracy skills were also associated with lower income among immigrants and native U.S. citizens (Batalova & Fix, 2015; Jonas, 2018; Patterson, 2019).

Numeracy Skills and Skill Use

Highly relevant to numeracy skills is the use of skills. Skills continue to develop across the lifespan, with gains and losses occurring. Factors predicting gains or losses in learning include sociodemographic characteristics measuring resourcefulness or social advantage, basic cognitive skills, and engagement in literacy and numeracy practices (Lechner, 2023). Practice engagement theory suggests that more use of numeracy skills predicts higher skill levels (Lechner, 2023; Reder et al., 2020). U.S. adult *use* of numeracy skills at home tends to increase as skill levels rise (Grotlüschen et al., 2016), and numeracy proficiency tends to benefit numeracy practices (Jonas, 2018). Conversely, authors of a recent latent class analysis reported that light numeracy users were less likely to use most numeracy skills at home than were other classes of numeracy use (Yamashita et al., 2022).

Type of numeracy used may vary for subpopulations, especially among adults considered vulnerable. For example, a German paper reported results on high use of calculating costs and budgets among vulnerable subgroups, including unemployed adults, homeless adults, and adults with high debt (Grotlüschen et al., 2019). Also, a recent U.S. study of numeracy skills and skills use of adult ELs (Patterson, 2020) found that ELs tended to use financial numeracy skills most often, including reviewing financial statements, conducting online transactions, and calculating costs or budgets. The majority reported using basic math less than monthly. Use of numeracy skills at home, on top of factors of EL education, health, and parental education, accounted for 40% of the variance in numeracy skills, with use of financial numeracy the strongest predictor (Patterson, 2020).

Numeracy skills and use may also predict health outcomes

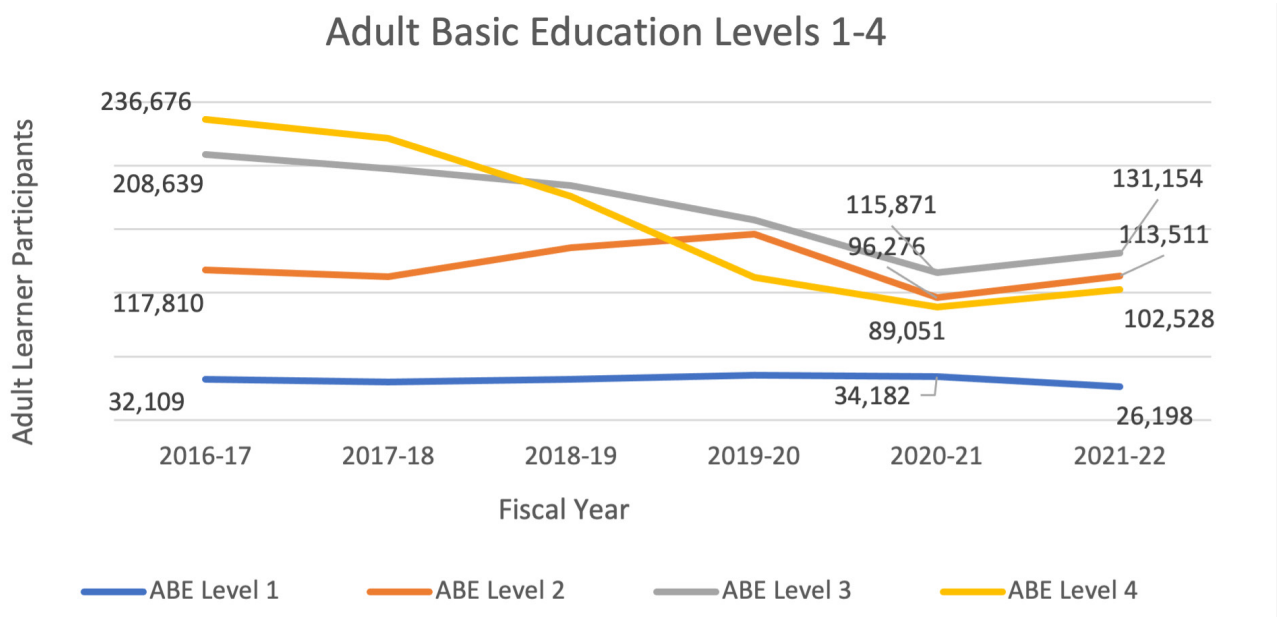
and behaviors (Jonas, 2018). Having strong numeracy skills may support adults to understand health risks, make informed health decisions, and manage health conditions (Feinberg et al., 2016; Jonas, 2018; Prins & Monnat, 2015). For example, compared with individuals having low numeracy skills, those with moderate to high numeracy skills were 156% more likely to have dental checkups (Yamashita et al., 2018). Oughton noted that the odds of fair or poor health quadrupled for adults with low numeracy skills and their children were more likely to have low skills (2018).

Challenges of Accessing Numeracy Learning for Adults with Low Skills

To gain numeracy skills and associated benefits, adults frequently seek out AFE services offered through federally funded Workforce Innovation and Opportunity Act (WIOA) programs or work with individual tutors, who are typically volunteers. ProLiteracy reported that its 5,000 U.S. community-based organizations, staffed primarily by volunteers, served more than 148,000 adult learners across 2.2 million volunteer hours (ProLiteracy, 2023). Accessing services to gain numeracy skills, however, is not always straightforward, particularly for AFE learners with the lowest skill levels. A 66% reduction in adult basic education (ABE) enrollment and 49% decrease in EL enrollment in WIOA programs occurred through 2020 (Pickard, 2022). Pickard understandably asked why fewer people enrolled; the answers are complex and involve changes in federal policy and accountability, stagnant federal funding, a shift in focus from HSE to workforce preparation, changes in learner interests, and very recent shifts to online learning. Pickard (2022) encouraged researchers to investigate factors related to declining enrollment.

Pickard's research did not address, however, whether differences occurred in enrollment or outcomes for the lowest levels of ABE learners and ELs since the pandemic. Pandemic restrictions from 2020 to 2022 added to learners' challenges, and especially caregiving women's, in accessing AFE; new challenges included adults' unemployment, food insecurity, illness, and supporting children's remote learning (Belzer et al., 2022). In spring 2020, an estimated 97% of AFE programs switched abruptly to remote instruction (Belzer et al., 2022). According to an AFE staff scan (Belzer et al., 2020), learners with low skills were most negatively impacted by transitioning online. AFE learners with low skills often "required additional help" to use online tools so "were less likely to continue" (Belzer et al., 2020, p. 9). Learner technology challenges were low digital literacy skills, limited (and costly) broadband access, and lack of devices.

FIGURE 1: U.S. Adult Learner Enrollment Trends



Source: National Reporting System Data, 2016-17 through 2021-22

An AFE program administrator remarked in 2021 that adults with "'lower level of literacy or technology are the ones suffering the most. They're not being served'" (Belzer et al., 2022, p. 8). These findings reinforce the need to know more about family situations and familiarity with technology of AFE learners with low numeracy skills.

In the context of pandemic shifts and WIOA, most ABE and EL levels in National Reporting System (NRS) data (https://nrs.ed.gov/) tended to experience enrollment loss from 2016-17 to 2020-21 (the first WIOA implementation year and the first full year of pandemic restrictions, respectively; see Figure 1). For example, from 2020-21 to 2021-22, the latest year available at time of writing, ABE Levels 2, 3, and 4 showed signs of rebounding, increasing 18%, 13%, and 15%, respectively, although not to pre-pandemic levels. An exception to this trend was ABE Level 1. In Figure 1, ABE Level 1 enrollment, the lowest level tracked in NRS, remained flat nationally between 2016-17 and 2020-21, with a 6% increase. Figure 1 shows that in 2021-22, ABE Level 1 enrollment decreased 23% compared with 2020-21 instead of rebounding like Levels 2 through 4. While it is uncertain how trends will continue, loss of AFE learners enrolling at the lowest level of ABE is discouraging, especially since adults at low levels have the strongest needs for numeracy.

For thousands who do enroll, gaining numeracy skills in AFE is critical. From 2018-19 through 2021-22, NRS collected data on percentages of adults achieving level gains in Mathematics (for example, moving from ABE Level 1 to 2, or higher) as measured by pre- and post-tests. Except during pandemic restrictions in 2020 and 2021, approximately half of ABE Level 1 learners gained numeracy skills. In 2018-19 and 2019-20, just under half of ABE Level 1 learners made Mathematics gains (46% and 43%, respectively). The 2020-21 percentage dropped to 25%, but by 2021-22 doubled to 53%. Where AFE learners could find ways past the challenges detailed earlier to enroll and stay in the AFE program, their chances of gaining numeracy skills appeared good.

Research Questions

Knowing more about AFE learners with low numeracy skills, including their characteristics, backgrounds, skill levels, and use of skills, is critical. To contribute to a deeper understanding of AFE learners with low numeracy skills, this paper, employing the PIAAC 2012/2014/207 dataset, addresses the following research questions:

1. What are the demographic characteristics of AFE learners – those participating in basic skills, HSE, and EL instruction (i.e., age, gender, race/ethnicity, partner and family status, health status, region of USA, income, native/immigrant status, English speaking ability, and length of residence in USA)?
2. What is the educational background and experience of AFE learners (i.e., education attainment, main reason for taking classes/tutoring, parental education, learning disabilities status, experience with computers in everyday life, six learning strategies, any uncompleted education, wanted education but did not start, and reason for not starting education)?
3. What are numeracy skill levels of AFE learners?
4. To what extent do AFE learners use numeracy skills overall and four basic numeracy skills at home (i.e., calculating costs, calculating fractions/percentages, using a calculator, and conducting financial transactions), and how do numeracy skills, with and without covariates, predict that use?

Methods

Sample

PIAAC is an international, multi-cycle survey of adult skills and competencies carried out by the OECD (Krenzke et al., 2020) in over 35 countries. The first cycle of PIAAC included three waves: 24 countries in 2011–12 (wave 1); nine additional countries in 2014–15 (wave 2); and five additional countries in 2017–18 (wave 3). In the United States, PIAAC surveyed individuals ages 16 – 74 years. Participating adult completed a background questionnaire (BQ) and took three assessments in domains of cognitive skill: literacy, numeracy, and problem solving in technology-rich environments. To provide a measure of uncertainty in cognitive skills, PIAAC used 10 plausible values (multiple imputations) based on IRT scaling of cognitive items with a latent regression model using BQ information. A set of weights for the combined PIAAC 2012/2014/2017 sample was created by combining the final PIAAC 2012/2014 and PIAAC 2017 weights and calibrating to population totals (Krenzke et al., 2020).

PIAAC numeracy levels are based on numeracy scores and range from below Level 1 to Level 5: 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 the PIAAC Technical Manual (Hogan et al., 2016). Level 1 numeracy tasks require the adult to carry out basic mathematical processes in common, concrete contexts. Tasks usually require simple one-step or two-step processes involving, for example, performing basic arithmetic operations; understanding simple percentages; or identifying and using elements of simple or common graphical or spatial representations (OECD, 2013). The PIAAC numeracy assessment contained 57 test items.

The PIAAC-USA restricted-use dataset from 2012/2014/2017 used for this paper contained a sample of 12,330 U.S. adults. While sample and replicate weights were available in the public-use files for 2012, 2014, or for 2017 separately, pooled data with combined weights were only available as restricted-use data (Krenzke et al., 2020). The chief advantage of restricted-use data is maximizing the number of AFE learners – a small PIAAC subgroup. To exclude young adults still in compulsory education, the sample was limited to 350 AFE learners who were at least 18 years old. The sample was selected from positive responses to three PIAAC questions about taking courses or tutoring, including 90 taking basic skills classes or tutoring, 150 in HSE preparation, and 110 English learners. This sample represents an estimated 5.2 million AFE learners.

Variables and Analyses

More than 40 variables were selected to describe the characteristics and educational backgrounds of AFE learners. Variables were analyzed using SPSS 26 and IDB Analyzer, a package incorporating PIAAC sample and replicate weights as well as plausible values for skills. Percentages, with standard errors (*SE*), were calculated to estimate AFE learner status and performance. Variables addressed learner type and reasons for taking classes/tutoring, age, gender, ethnicity, and U.S. geographic region (NCES, 2019). Employment variables were employment status, including unemployment, monthly salary, and hourly wage. Education background variables included highest education level, uncompleted education, training not started and reasons for not starting, six learning strategies, parental education, and experience with computers. Family-related variables measured partner status and information about children. Immigrant information included birth and language status and English-speaking ability. Health-related variables were health status, difficulty seeing print, and diagnosed learning disabilities.

Numeracy skills were measured employing 10 plausible values for numeracy as described earlier. Advanced numeracy skills measured in PIAAC included preparing charts or graphs, using simple algebra or formulae, and using statistics or advanced math (e.g., trigonometry or calculus). A separate analysis examined frequency of use (never, less than monthly, monthly, weekly, and daily) of four basic numeracy use types: calculating costs and budgets (H_Q03B), calculating fractions or percentages (H_Q03C), using a calculator (H_Q03D), and using the internet to conduct financial transactions (H_Q05D).

For linear regression models, the first dependent variable was a derived index of use of basic and advanced numeracy skills (NUMHOME), ranging from -0.5 to 6.2 with mean of 2.3. The second dependent variable (NUMERACYUSE) was use of basic numeracy, with four basic numeracy use variables (described in the previous paragraph) summed to create a composite of use, with a range of 4 to 20. Hypothesized covariates from the literature review were age, partner status, parent status, education attainment, personal reasons for adult learning, and gender (NCES, 2019). A second pair of models predicted basic numeracy use from numeracy skills alone and separately from numeracy skills with the same covariates. Regression coefficients are standardized betas (*B*) for individual predictor variables. R^2 is the effect size for each model and measures the extent to which numeracy skills (and covariates) predict use of numeracy.

Results

Demographic Characteristics

The 350 adults in the PIAAC sample of adults taking AFE classes or tutoring ("AFE learners") represented an estimated 5.2 million AFE learners; all results in the following sections were weighted. To address RQ1, AFE learners ranged in age from 18 – 67 years, with a median age of 24 years. In contrast, median age was much higher, 43 years, with a range of 16 –74 years, for the full sample of 12,330 adults. Half of AFE learners were men (see

Table 1). Ethnically, most AFE learners were Hispanic or White; in the full sample, two-thirds of adults were White. Regionally, most AFE learners lived in the South or West.

In the full sample, two-thirds of adults were living with a partner or spouse and were parents, with a median two children (range 1 – 19 children). AFE learners, though generally much younger, had family responsibilities, too (see Table 1). Two-fifths were living with a spouse or partner, and nearly half were parents, with a median two children (range 1 – 8 children).

AFE learners also tended to have work responsibilities. Two-thirds of AFE learners were employed, with three-fifths working full time; 1 in 8 were unemployed, and 1 in 5 were out of the labor force. In contrast, full-sample adults had higher rates of full-time employment and an unemployment rate less than half the AFE learner rate.

TABLE 1: Demographic Characteristics of AFE Learners and the Full PIAAC Sample

Characteristic	AFE Learner % (SE)	Full PIAAC Sample % (SE)
N	350	12,330
GENDER		
Male	53.2 (3.7)	49.0 (0.0)
Female	46.8 (3.7)	51.0 (0.0)
ETHNICITY		
Asian or Pacific Islander	8.4 (2.3)	5.0 (0.4)
Black	19.0 (2.8)	12.4 (0.1)
Hispanic	41.2 (3.3)	14.2 (0.3)
White	30.2 (3.6)	65.7 (0.5)
U.S. REGION		
Midwest	16.5 (3.1)	21.1 (0.0)
Northeast	12.3 (2.8)	17.9 (0.0)
South	40.4 (3.7)	37.4 (0.0)
West	30.8 (3.8)	23.6 (0.0)
PARTNER OR SPOUSE	37.7 (4.0)	66.6 (0.5)
PARENT OF CHILDREN	46.3 (3.8)	66.1 (0.5)
EMPLOYED	67.6 (3.0)	70.7 (0.5)
Full time	61.2	79.3
Part time	38.8	20.7
UNEMPLOYED	12.9 (1.8)	5.2 (0.0)
NOT IN LABOR FORCE	19.5 (3.0)	24.1 (0.5)
IMMIGRANT	42.7 (3.5)	14.1 (0.4)
NON-NATIVE ENGLISH SPEAKERS	45.6 (3.5)	18.1 (0.4)
SPOKE ENGLISH NOT WELL OR NOT AT ALL	21.5 (2.8)	3.6 (0.2)
HEALTH		
Excellent or good	86.2 (3.5)	83.6 (0.5)
Fair or poor	13.7 (2.0)	16.4 (0.5)
DIFFICULTY SEEING PRINT	11.9 (2.4)	12.3 (0.3)
LEARNING DISABILITIES	14.6 (2.4)	8.0 (0.3)

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.

AFE learner earnings were low; median wage was $10/hour (range $1.11 - $41.67), lower than $16.70/hour in the full sample. For AFE learners earning monthly salaries, the median was $1,515.67 (range $0 - $12,500 monthly), about half the full sample rate ($2,916.70 monthly).

Two-fifths of AFE learners were born outside the USA, triple the full-sample rate. Nearly half of AFE learners were not native English speakers. Immigrant ELs indicated being in the USA a median 11 years (range 0 – 53 years). Only 1 in 5 ELs spoke English not well or at all – this rate was six times the full-sample rate, however.

Nearly all AFE learners reported good to excellent health, with 1 in 7 reporting fair or poor health and 1 in 10 difficulty seeing print. A high proportion of AFE learners reported being diagnosed with learning disabilities (LD), at nearly twice the full-sample rate.

Educational Background and Experience

The second research question addressed AFE learners' background and experience with education. Overall, one-third had not completed high school (see Table 2), almost triple the full-sample rate. Half of AFE learners were high school graduates, and the remaining 1 in 10 had at least some postsecondary education (PSE), at one-fourth the full-sample rate. Nearly one-third of AFE learners had parents not completing high school, higher than the full-sample rate, yet one-third of AFE learners each had at least one parent who did complete high school, or one or both parents with PSE. Nearly all had experience using computers at home (see Table 2). Many AFE learners were involved in both learning basic skills and HSE preparation in the past year; a 37% overlap occurred among adults learning basic skills and adults preparing for HSE.

AFE learners reported the main reasons for learning were personal interest or personal and work-related reasons equally, as shown in Table 2; fewer than 1 in 5 reported learning only for work-related reasons. These rates were similar to full-sample rates.

Responses on strategies AFE learners use in learning indicated they generally enjoyed learning and taking on learning challenges – at rates remarkably similar to full-sample rates. Most liked learning new things to a high or very high extent, could look for additional information, could attribute something new, liked to get to the bottom of difficult things, and could figure out how different ideas fit together. However, only two-fifths could relate ideas they learned into daily life (see Table 2).

In keeping with their AFE learner status, three-fifths reported no learning activities that they wanted to start within the past year but did not – a rate nearly twice the full-sample rate. Those facing learning barriers in the past year most often reported work schedule or family responsibilities keeping them too busy; 1 in 8 indicated classes were offered at an inconvenient time or place. These rates of barriers were similar to full-sample rates. One exception was cost; since AFE learner costs are minimal, only 1 in 10 could not afford the cost, half the full-sample rate.

Complementing these findings, many AFE learners experienced leaving education before completion; one-third indicated uncompleted education (see Table 2). Among those with uncompleted education, 47.1% had not completed high school or earlier grades, and 52.8% had attempted yet not finished PSE, often career-technical education (CTE; 25.4%), associate degree program (14.3%), or bachelor degree program (13.3%). In the full sample, only 7.4% had not completed high school, with nearly all leaving PSE programs.

AFE learners left their education experience a median 10 months earlier (range 0 – 21 months) at ages ranging from 13 – 54 years, median age 21 years. The most prevalent single age for uncompleted education was 17 years for AFE learners and age 20 for full sample, and a fourth of AFE learners left school before age 18, much higher than 4.7% in the full sample.

Numeracy Skills and Use

RQ3 and 4 addressed numeracy skills and skill use of AFE learners. The average numeracy score of AFE learners was 218.6 (*SE* 4.4, *SD* 51.3), placing them in numeracy Level 1, well below the Level 2 numeracy of adults in the full sample (average 255.5, *SE* 0.9, *SD* 56.5). Learners participating in basic skills averaged 237.5 (*SE* 8.2, *SD* 46.0), HSE learners had a mean numeracy score of 203.9 (*SE* 6.6, *SD* 44.7), and ELs averaged 216.4 (*SE* 7.3, *SD* 55.7).

AFE learners tended to use basic numeracy skills regularly – the median overall index of use at home was between 60% and 80%, distinct from the full-sample median of

TABLE 2: Education Background of AFE Learners and the PIAAC Population

Background Characteristic	AFE Learner % (SE)	Population % (SE)
N	350	12,300
EDUCATION ATTAINMENT		
Less than high school	37.9 (3.5)	13.1 (0.2)
High school completion	51.1 (4.1)	40.5 (0.4)
Some PSE or college degree	11.0 (1.9)	46.3 (0.4)
PARENT EDUCATION ATTAINMENT		
Less than high school	30.7 (2.9)	17.8 (0.5)
High school completion	34.4 (3.4)	42.4 (0.7)
Some PSE or college degree	34.8 (3.0)	39.8 (0.7)
EXPERIENCE USING COMPUTER AT HOME	82.1 (2.8)	85.3 (0.5)
REASON FOR LEARNING		
Personal interest	45.1 (4.1)	47.7 (3.1)
Work-related interest	18.5 (3.1)	18.2 (2.4)
Personal and work equally	35.4 (3.9)	34.1 (2.6)
LEARNING STRATEGIES		
Liked learning new things	84.0 (4.2)	80.1 (0.6)
Could look for additional info	77.9 (3.4)	79.5 (0.7)
Could attribute something new	65.7 (3.8)	68.0 (0.6)
Liked to get to the bottom of things	66.1 (3.2)	68.9 (0.6)
Could figure out how ideas fit	61.6 (3.7)	61.1 (0.6)
Relate ideas they learned to life	40.2 (3.3)	46.4 (0.5)
LEARNING BARRIERS		
Desired learning not started	59.1 (3.1)	33.1 (0.7)
Work schedule keeps too busy	27.9 (5.9)	28.2 (0.9)
Childcare / family responsibilities	19.1 (4.8)	15.1 (0.7)
Class time or place is inconvenient	12.9 (4.8)	12.8 (0.6)
Cannot afford costs of learning	10.1 (3.0)	21.1 (1.0)
PREVIOUS UNCOMPLETED EDUCATION		
Left earlier education uncompleted	33.4 (3.1)	29.1 (0.6)
Left education at age 17	15.9 (5.2)	2.3 (0.3)

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.

40% to 60%. Nearly half of AFE learners reported using calculators; 22.5% used a calculator daily and 25.6% did so weekly (see Table 3). Another 32.1% used numeracy daily to calculate costs or budgets and 29.4% did so weekly. However, fewer AFE learners (15.8%) calculated fractions or percentages daily or weekly (23.6%). Similarly, few AFE learners went online to conduct financial transactions – only 18.0% daily and 24.9% weekly. Rates approximate full-sample rates, except AFE learners had higher rates of never conducting online financial transactions and of daily use of calculators and calculating costs or budgets (see Table 3).

To address RQ4, regression analyses first examined how numeracy skills, with and without covariates, predicted use of basic and advanced PIAAC numeracy skills at home. In model 1, as shown in Table 4, numeracy skills alone were a significant predictor yet explained only 6% of variability in numeracy use. Model 2 added covariates for age, no partner/spouse, not having children, less than high school education attainment, having personal reasons for classes/tutoring, and female gender. In this model, numeracy skills with covariates explained 22% of variability in basic and advanced numeracy use. Numeracy skills with covariates were stronger predictors of overall

TABLE 3: Basic Numeracy Skill Use of AFE Learners

Numeracy Skill Use	Daily % (SE)	Weekly % (SE)	Monthly % (SE)	Less Than Monthly % (SE)	Never % (SE)
USE A CALCULATOR					
AFE learners	22.5 (2.5)	25.6 (3.2)	16.7 (2.8)	18.4 (2.7)	16.7 (2.5)
Full Sample	15.4 (0.4)	34.1 (0.5)	21.5 (0.5)	14.6 (0.4)	14.4 (0.4)
USE OR CALCULATE FRACTIONS OR PERCENTAGES					
AFE learners	15.8 (2.3)	23.6 (2.5)	11.9 (2.2)	14.3 (2.4)	34.4 (3.9)
Full Sample	14.2 (0.3)	23.8 (0.5)	17.4 (0.4)	17.5 (0.4)	27.1 (0.5)
CALCULATE COSTS OR BUDGETS					
AFE learners	32.1 (3.0)	29.4 (3.3)	13.1 (2.3)	7.5 (1.5)	17.9 (2.4)
Full Sample	22.0 (0.5)	33.8 (0.4)	18.9 (0.4)	12.7 (0.3)	12.6 (0.4)
CONDUCT FINANCIAL TRANSACTIONS ONLINE					
AFE learners	18.0 (3.0)	24.9 (3.5)	16.9 (3.1)	17.5 (3.2)	22.6 (3.1)
Full Sample	17.9 (0.6)	33.9 (0.7)	21.9 (0.4)	13.4 (0.4)	12.9 (0.4)

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 use, significantly for unmarried adults and men, than numeracy skills alone. Age, no children, less than high school attainment, and having personal reasons for classes/tutoring were not significant in model 2.

Next, regression analyses considered how numeracy skills, individually (model 3) and then with covariates (model 4), predicted use of four *basic* numeracy skills at home (see Table 3). Numeracy skills alone explained 9% of variability in basic numeracy use (see Table 5). Numeracy skills with covariates (model 4) explained 26% of variability in use of basic numeracy. Significant predictors were numeracy skills, age, partner/spouse status, and gender. Model 4 better predicted basic numeracy use, accounting for younger age, unmarried adults, and men, than did numeracy skills alone. Having children, less than high

TABLE 4 Predicted Numeracy Skill Use of AFE Learners from Numeracy Skills and Covariates in Models 1 and 2

Model and Variables	B*	(SE)	p	R^2 (SE)
1. BASIC AND ADVANCED NUMERACY USE AT HOME (*n*=350)				0.06 (0.03)
Numeracy skills	0.24	0.07	< .001	
2. BASIC AND ADVANCED NUMERACY USE AT HOME (*n*=220)				0.22 (0.06)
Numeracy skills	0.27	0.09	< 0.01	
Age	-0.12	0.08	NS	
Not having a partner/spouse	0.16	0.08	0.05	
Not having children	0.00	0.10	NS	
Less than high school education attainment	0.02	0.08	NS	
Having personal reasons for classes/tutoring	0.11	0.08	NS	
Female gender	-0.21	0.10	< 0.05	

*Standardized coefficient (B). 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.

school attainment, and personal reasons for classes/tutoring were not significant in model 4.

Discussion

Challenges to AFE Learners

Broadly, AFE learners face many challenges – in employment, uncompleted education, and health/disability concerns. Economically, their high unemployment rate (nearly 13%) was even higher than 5% in the full sample. For employed AFE learners, a high rate of part-time employment and median hourly wage of $10, or monthly salary of almost $1,516 (roughly $18,000 annually), does not bode well supporting a family long term. Findings on how low numeracy relates to low income align with those of Jonas (2018) for native speakers and of Batalova and Fix (2015) for immigrants.

Additionally, many AFE learners already experienced leaving education before completion; not surprisingly, half left high school without completing. Given generally low numeracy skills, even those completing secondary education may have been unprepared for CTE or other PSE programs. This finding has implications for instruction in that AFE learners – whether native speakers or ELs – need to continue strengthening numeracy skills to successfully complete education credentials they want (Bergson-Shillcock, 2017; Grotlüschen, 2018; Patterson, 2020). Teaching skills in context of numeracy at home or in the CTE/academic PSE classroom has potential to support both uses. The desire of three-fifths of AFE learners to strategically relate ideas they learn into daily life also supports contextual numeracy instruction.

A third set of challenges encompasses health and disability concerns. Although health concerns were generally low, nearly 12% indicated difficulty seeing print, which hampers ability to see and calculate numbers or do online financial transactions (Patterson, 2019). Also, nearly 15% of AFE learners reporting an LD diagnosis presents an even higher rate than recent previous research found for adults with low numeracy skills (learners or not; Patterson, 2023).

Opportunities of AFE Learners

On the plus side, AFE learners have several numeracy-related opportunities – namely, solid EL representation among AFE learners, interest in learning strategies, and computer experience at home. The strong representation in PIAAC of ELs (31%) among AFE learners is a plus considering less than a fourth of immigrants rated their English-speaking ability not well or at all. Approximately half of ELs appeared to have strong personal reasons to learn English. Although ELs' numeracy skill average was slightly higher than the 208 average of immigrants overall (Saal et al., 2018), both groups are still at Level 1 in numeracy, leaving plenty of opportunity for numeracy instruction.

AFE learner interest in learning strategies appeared high, offering another opportunity. Responses on strategies AFE

TABLE 5 Predicted Numeracy Skill Use of AFE Learners from Numeracy Skills and Covariates in Models 3 and 4

Model and Variables	B*	(SE)	p	R^2 (SE)
3. BASIC NUMERACY USE AT HOME (*n*=350)				0.09 (0.04)
Numeracy skills	0.30	0.07	< .001	
4. BASIC NUMERACY USE AT HOME (*n*=240)				0.26 (0.09)
Numeracy skills	0.21	0.10	< 0.05	
Age	-0.23	0.09	0.01	
Not having a partner/spouse	0.20	0.08	0.01	
Not having children	-0.08	0.09	NS	
Less than high school education attainment	-0.08	0.07	NS	
Having personal reasons for classes/tutoring	0.03	0.08	NS	
Female gender	-0.18	0.09	< 0.05	

*Standardized coefficient (B). 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.

learners use in learning indicated they generally enjoyed learning and taking on learning challenges. Where adult educators and tutors can connect the joy of learning new things to numeracy – whether seeking additional information or attributing something new – the potential for learning rises. Also, two-thirds of AFE learners like to get to the bottom of difficult things or figure out how different ideas fit together, and both strategies tie in well with instructional approaches to solving numeracy problems. A first potential resource instructors and tutors could consider on numeracy strategies is a 2023 LINCS module for professional learning on universal design in Making Math Matter (available at https://lincs.ed.gov/state-resources/federal-initiatives/udl). Instructors and tutors will find additional strategic resources for designing numeracy instruction in Curry's (2019) *PIAAC Numeracy Framework: A Guide to Instruction* (available at https://files.eric.ed.gov/fulltext/EJ1246047.pdf). Employing these resources along with general instructional practices – such as using numbers in everyday situations, financial numeracy, measurement, and recipes – might further enhance numeracy use at home.

A last opportunity related to numeracy was computer experience at home. Four-fifths of AFE learners had experience using computers at home. This finding does not mean AFE learners are fully adept at using computers or comfortable with online learning; in fact, findings on online financial transactions indicate two-fifths of AFE learners seldom or never do so. They may also struggle with using computers for learning (Belzer et al., 2020). Still, experience with using computers indicates having some basic digital skills as a starting point for numeracy instruction. Since data were collected before the 2020-22 pandemic, shifts in online numeracy instruction and learner outcomes likely occurred in the interim (Belzer et al., 2022).

Numeracy Skills and Predicting Numeracy Use from Numeracy Skills

Average numeracy scores of AFE learners were generally at Level 1, well below Level 2 numeracy of U.S. adults overall. AFE learners in HSE and ELs were in Level 1 for numeracy, and basic skills learners averaged in Level 2. One explanation for this counter-intuitive subgroup finding is moderate overlap among adults in basic skills classes/tutoring and adults preparing for HSE – adults taking the BQ may have interpreted "basic skills" differently from its standard AFE use as representing ABE Levels 1-4.

Whether at Level 1 or 2 in numeracy, AFE learners clearly have needs for stronger numeracy skills, as found in previous research (Jonas, 2018; Oughton, 2018; Patterson, 2020, 2023; Saal et al., 2018; Sands et al., 2018). Not having skills may leave them vulnerable (Gal et al., 2020), especially if they are unemployed, have low income, or are in debt (Grotlüschen et al., 2019). Declining learner enrollment (Pickard, 2022) and pandemic-related instructional shifts in 2020 (Belzer at al., 2020, 2022) likely hampered strengthening numeracy skills beyond fundamental levels.

Encouraging findings from this paper include numeracy skills and covariates positively predicting AFE learners' use of numeracy skills at home. Marital status and gender may be supportive factors to using numeracy at home, particularly for single adults and men. Findings do not imply that partnered adults or women do not use numeracy skills at home, rather that, combined with numeracy skills they have, they tend to use numeracy skills less. Awareness of this finding can help instructors or tutors to encourage married adults and women to gain and use numeracy skills.

Also worth noting is, beyond an adult's numeracy skill level, having children, less than high school education attainment, and personal reasons for classes/tutoring did *not* significantly predict numeracy skill use. These characteristics may simply be prevalent among AFE learners regardless of numeracy skill use. Moreover, for the combined four *basic* skills involving calculations and financial transactions, (younger) age is a significant predictor; older adults may need more instruction or tutoring in numeracy skills to strengthen both skills and use of basic numeracy skills at home.

Findings add to results from recent practice engagement research (Lechner, 2023; Reder et al., 2020; Yamashita et al., 2022). Since numeracy skill use at home tends to increase as skill levels rise (Grotlüschen et al., 2016), given these new findings, instructional efforts to strengthen numeracy skills show promise to support skill use. Since practice engagement posits that using skills also strengthens them (Lechner, 2023; Reder et al. 2020),

having learners simultaneously use and learn numeracy skills can support positive numeracy growth and lessen vulnerability. Use of resources suggested in this paper and its numerous references may benefit instructors, tutors, and AFE learners as learners practice and strengthen numeracy skills.

At this paper's start, the importance of seeking solutions to engage more adults in AFE was noted, and solutions are especially important to engaging adults with low skills. How programs brand their services and respond to adult's goals for learning is crucial to engagement. Labels as an HSE, English learning, or workforce program will not adequately communicate the breadth or value of available services for gaining numeracy skills and use. Adults needing numeracy skills will see themselves as welcome in programs where services offer explicit engagement in such topics as numbers in everyday situations, financial numeracy, and measurement; where, with instructional support, learners learn about these topics digitally; and where older adults, ELs, adults with disabilities, and other adults wanting to refresh basic numeracy skills can explore numeracy goals, participate in instruction or tutoring matched to goals, and practice their numeracy skills with other adults.

Limitations and Future Research

Noting limitations in sampling and regression analysis will help readers further understand the context of findings. Limiting the dataset to adults at least age 18 helped avoid including secondary students in compulsory education but likely excluded young adults ages 16 and 17 years who left high school early. PIAAC contains no precise indicator of "in compulsory education", so PIAAC researchers frequently limit by age to exclude secondary students from samples.

A limitation connected to future research is lack of correspondence between PIAAC and NRS levels. AFE learners in basic skills, HSE preparation, and EL programs were likely placed at different ABE or ESL skill levels, as measured by the NRS, than were measured in levels of PIAAC numeracy. Since PIAAC offers a cross-sectional dataset, it does not purport to measure AFE learner outcomes. Future researchers could compare cycles of PIAAC data for AFE learners and changes in numeracy skills that occurred. These comparisons would be particularly meaningful for the high proportion of AFE learners with disabilities and for those studying health concerns.

Also, in regression analyses, a relatively small number of covariates were included (compared with prior numeracy studies). The degrees of freedom were limited because of IDB Analyzer's listwise deletion structure. Therefore, when covariates were included in models, the number of learners decreased to 220 (for the first two models) and 240 (for third and fourth models), so a maximum six covariates and numeracy skills could enter models to reliably predict skill use. Future researchers could consider ways to expand the overall sample of AFE learners or employ a future indicator of leaving high school early that was proposed for PIAAC cycle two, with results released in December 2024.

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