Individual and Prison Factors Influencing Incarcerated Adults' Literacy and Numeracy Skills in the United States

by

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ABSTRACT

Incarcerated adults demonstrate substantially weaker numeracy and literacy skills compared to adults in the general population; nonetheless, little is known about the skills of incarcerated adults. Therefore, the purpose of this study was to examine individual and prison factors influencing the literacy and numeracy skills of offenders in the United States. The sample included 1,247 inmates from the Program of International Assessment of Adult Competencies. Path analysis results revealed educational attainment, native language, and book exposure were statistically significant predictors of skills. Although demographics were related to differences in performance, these effects appeared to be related to other variables. Finally, prison job training and engagement in numeracy activities were statistically significant predictors for numeracy. Findings from this study provide empirical evidence on how prison factors may influence the literacy and numeracy performance of inmates from diverse backgrounds. The findings also suggest a need for a closer evaluation of prison programs.

INDEX WORDS: Numeracy, Literacy, Skills in prison, Incarcerated adults, Prison factors, Individual factors, International assessments, PIAAC

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DEDICATION

First and foremost, I am thankful to God for guiding me on this journey and for continually providing me with the strength and support that I need. This work is a dedication to God in honor of the blessings he has given me. I am also grateful to my loving family, who have always been my biggest supporters and sources of inspiration. Your prayers and belief in me have kept my motivation high and have made this journey possible. This thesis is dedicated to you with all my love and gratitude.

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1 INTRODUCTION

Literacy and numeracy proficiencies are essential to understanding and using information embedded in various contexts such as work, school, and health and risk management settings (Meisels, 2010). Furthermore, higher literacy and numeracy skills are associated with better educational, occupational, and health outcomes (Cai et al., 2019). Similarly, high literacy and numeracy skills are also beneficial to societies at large since adults with higher skills contribute positively to countries' economies (Cai et al., 2019). Unfortunately, studies indicate that incarcerated adults in the United States are a vulnerable group with substantially lower skills and educational attainment compared to their non-incarcerated counterparts in the general population (Cai et al., 2019; Patterson, 2018; Rampey et al., 2016). For instance, compared to 48% of the general population, 81% of incarcerated adults exhibit low performance in literacy and numeracy (Cai et al., 2019). Moreover, it is estimated that 30% of the incarcerated adult population lack a high school level of educational attainment compared to 14% of the general population (Rampey et al., 2016). Considering the positive influence of higher skills on individual and societal outcomes, it is important to investigate factors influencing inmate' literacy and numeracy skills to better understand the lower skill rates among incarcerated adults. As a result, this would provide empirical evidence on the extent to which various factors impact inmates' literacy and numeracy skills and would inform policymakers and stakeholders on the effectiveness of prison programs and activities.

The prison population is predominantly young, male, and from racially minoritized backgrounds (Beatty & Snell, 2021). Nevertheless, there is little research on how individual factors affecting inmates' literacy and numeracy proficiencies differ based on gender, age, and race (Cai et al., 2019; Olaghere et al., 2021). Therefore, this study aims to examine how incarcerated adults' background characteristics (e.g., demographics and parental education) and activities before incarceration (e.g., educational attainment and the number of books at home) affect their literacy and numeracy proficiencies during incarceration.

While it is crucial to account for factors associated with individuals' backgrounds (e.g., parental education and socioeconomic status), such factors are fixed and unchangeable (Koo, 2016). Meanwhile, correctional education and prison programs are malleable factors worth examining because they could inform policymakers and stakeholders on which prison programs and opportunities impact incarcerated adults' skills (Koo, 2016)—especially considering that educational and training programs provide opportunities for incarcerated adults to develop and apply their literacy and numeracy skills (Reder et al., 2020; Vera-Toscano et al., 2017).

Several recent studies using the PIAAC prison data have examined predictors of numeracy and literacy in incarcerated adults (Cai et al., 2019; Olaghere et al., 2021; Patterson, 2018; Reder, 2019; Renbarger et al., 2019). However, research is still limited on the extent to which various prison factors influence performance. Thus, this study aims to investigate the relationship between various prison factors and incarcerated adults' literacy and numeracy skills. Additionally, to account for the influence of background characteristics on prison factors, this study will examine the extent to which the effects of participation in prison programs differ based on race, age, and gender and whether these differences are associated with substantial changes in literacy and numeracy proficiencies.

1.1 The Impact of Individual Factors on Adults' Literacy and Numeracy Skills

1.1.1 Demographics of the Prison Population in the United States

Approximately two million individuals are incarcerated in the United States (Sawyer & Wagner, 2022), which places the U.S. as the leader in incarceration worldwide (Cai et al., 2019;

Shippen et al., 2010). It is estimated that 93% of the prison population are males, and 58% are between the ages of 25-44 (Beatty & Snell, 2021). Ethnic minorities are overrepresented in the prison population compared to the general population, with Black adults representing 37% of incarcerated adults compared to 12% in the general US population (Rampey et al., 2016). Additionally, 22% of the prison population is Hispanic compared to 14% of the general population (Rampey et al., 2016). Considering the diversity of the prison population, it is vital to explore demographic differences as they relate to incarcerated adults' literacy and numeracy skills and their participation in various prison programs and activities.

1.1.1.1 Gender

Although there is considerably less research on incarcerated women than men, a recent study using data from the Program of International Assessment of Adult Competencies (PIAAC) showed that, on average, incarcerated women had higher educational attainment than incarcerated men (Patterson, 2018). Nevertheless, incarcerated men and women with less than a high school education exhibited comparably lower literacy and numeracy skills than adults in the general population (Patterson, 2018). Still, more research is needed on how incarcerated men and women from all education levels differ in literacy and numeracy skills.

1.1.1.2 Age

Age is a critical variable to examine in this study, as previous research has suggested that there are significant differences in literacy and numeracy skills of incarcerated adults based on age. For example, a study by Shippen et al. (2010) with incarcerated adults in a prison in Alabama showed that younger, male incarcerated adults were more likely to keep improving their basic literacy and reading skills than older incarcerated adults. Shippen et al. (2010) hypothesized that older inmates already had higher literacy skills, so they did not benefit from interventions like younger inmates. Comparatively, Renbarger et al.'s more recent study (2019), based on the PIAAC data, found that younger incarcerated adults exhibited higher skills in both literacy and numeracy than older incarcerated adults. Renbarger et al. (2019) hypothesized that younger adults have generally higher skills when entering prisons than older adults due to recent educational initiatives focusing on applied learning. Considering the dissimilarities in hypotheses related to the role of age on performance, evaluating how various factors relate to inmates' skills based on age might help elucidate performance differences between young and older inmates. Specifically, further investigation is required to examine whether the types of prison programs and activities that younger versus older adults participate in might contribute to differences in their literacy and numeracy skills.

1.1.1.3 Race

Research suggests that the inequities and racial disparities present in the general population are exacerbated in the prison population, meaning that minoritized groups in prisons are at a disadvantage in relation to their literacy and numeracy skills (Olaghere et al., 2021). Unfortunately, research is limited on racial differences in literacy and numeracy performance in the prison population. Rampey et al. (2016) showed that incarcerated adults identifying as Black and Hispanic demonstrated significantly lower numeracy skills, on average, than Black and Hispanic adults in the general population. However, no significant differences were found as related to their literacy skills. Another study by Shippen et al. (2010) found significant differences in the basic literacy skills of incarcerated males based on their race. The study showed that while European Americans performed significantly better than African Americans and Hispanics, and African American inmates outperformed Hispanic inmates on the literacy assessment (Shippen et al., 2010). However, the study measured literacy skills based on reading comprehension, and the collected data was from only one prison in Alabama, so the results are not necessarily representative of all prisons in the U.S.

While the studies mentioned above highlight differences based on racial backgrounds, they either examine racial differences in literacy performance only, or they examine literacy and numeracy performance without specifying prison factors influencing these racial differences. Therefore, it is essential to examine further the extent to which background and prison factors influence literacy and numeracy performance and how these factors differ among incarcerated adults from racially minoritized backgrounds.

1.1.2 Native Language Status, Parental Education, and Number of Books at Home

Because literacy and numeracy skills are embedded in daily living situations, these skills are influenced by people's backgrounds (Reder et al., 2020). Background characteristics, such as native language status, parental education, and the number of books at home, have been shown to influence the development of literacy and numeracy skills.

Olaghere et al., (2021) found that incarcerated adults who were native English speakers had higher literacy and numeracy proficiency compared to non-native English speakers. Considering that previous research by Shippen et al. (2010) showed that Hispanics demonstrated the lowest basic literacy skills, it may be important to examine the native language as an influential factor of literacy and numeracy skills of incarcerated adults.

Additionally, higher numeracy and literacy skills among individuals can be linked to parental education. A study by Finnie and Meng (2007) with adults in the general population found that parents of high school graduates demonstrated higher levels of education compared to parents of high school dropouts among adults with higher literacy and numeracy skills.

Similarly, research by Patterson (2018) showed that incarcerated adults with low levels of education often had parents with low education or no education.

In addition to native language status and parental education, early reading opportunities and book exposure are associated with later academic success and educational gains (Lonigan et al., 1999). Research shows that home library size is related to literacy and numeracy practices and competencies (Sikora et al., 2019). In a study on the impact of library size and book exposure on adolescents, exposure to books was related to long-term benefits in literacy and numeracy, meaning individuals had more engagement in these practices that continued into adulthood (Sikora et al., 2019). Therefore, it may be informative to examine the relationship between the number of books at home and incarcerated adults' literacy and numeracy skills.

1.1.3 Health Status

Health status has been shown to affect social and learning outcomes and create a barrier for incarcerated adults to pursue learning opportunities (Patterson, 2018). Low literacy and numeracy skills are often tied to low health status because adults with lower skills struggle with understanding medical information and healthcare management (Fagerlin et al., 2007; Gates & Bradford, 2015). In the incarcerated population, data show that 13% of inmates have hypertension, 6% have heart problems, 4% have diabetes, and 44% have a history of alcohol abuse (Maruschak, 2008). Considering the high rates of poor health conditions in the prison population, health status may prevent inmates from participating in prison programs and activities (Cai et al., 2019). Therefore, it is important to understand the relations between incarcerated adults' health status and their performance on numeracy and literacy assessments.

Additionally, a study by Patterson (2018) using the PIAAC prison data found that incarcerated women reported poorer health than incarcerated men. However, little research has explored the relations between health reports and literacy and numeracy performance while taking into account race, age, and gender differences. Therefore, this study will examine the extent to which performance in the literacy and numeracy domains is influenced by health status.

1.1.4 Educational Attainment

Education plays an essential role in career and financial outcomes. In the general population, it is estimated that individuals with post-secondary education have 37% increase in earnings compared to adults with secondary education (Lane & Conlon, 2016). Furthermore, educational programs can provide means for engagement and utilization of literacy and numeracy skills (Vera-Toscano et al., 2017).

Unfortunately, research shows that one in three adults in prison does not have a high school level education, and inmates further lack the literacy and numeracy skills needed for the ever-changing economies and labor market (Cai et al., 2019). As a result, incarcerated adults with low literacy and numeracy skills and low levels of education struggle to find employment after their release, which leaves them at a higher risk of recidivating (Davis et al., 2013; Esperian, 2010; Steurer & Smith, 2003). Because of the importance of educational attainment, this study will account for the level of education attained prior to incarceration and examine the extent to which it influences performance.

1.2 Prison Factors and Their Influence on Literacy and Numeracy Skills

The prison factors selected for this study are based on their malleability and potential to provide opportunities to improve literacy and numeracy skills, as applying what is learned is instrumental in shaping and improving individuals' skills (Reder et al., 2020).

1.2.1 Participation in Prison Educational and Vocational Opportunities

Research shows that participation in correctional education is linked to improving literacy and numeracy skills (Cai et al., 2019). For example, incarcerated adults who participated in academic programs in prison scored significantly higher in the PIAAC literacy and numeracy assessments (Rampey et al., 2016). Furthermore, 61% of incarcerated adults held a prison job, and those with a prison job scored significantly higher only in literacy. Still, incarcerated adults who participated in job training scored significantly higher in both literacy and numeracy (Rampey et al., 2016). Therefore, prison jobs, training, and educational programs can offer invaluable opportunities that improve incarcerated adults' literacy and numeracy skills.

Moreover, participation in correctional programs and training helps incarcerated adults reintegrate successfully into society and also helps reduce state funding for imprisonment costs. Steurer & Smith (2003) found that approximately 24 million dollars were saved per year in the State of Maryland by individuals who participated in correctional education and did not recidivate after their release. Nationally, higher participation in prison programs, especially vocational programs that improve employment outcomes for inmates, results in the "savings of hundreds of millions of dollars per year" when inmates do not recidivate (Vacca, 2004, p. 299).

However, incarcerated adults do not always see the relevance of correctional programs or how they can relate them to occupational and educational opportunities after their release from prison. Patterson (2018) revealed that 7 in 10 incarcerated adults had difficulties applying learned information in their daily lives or relating them to new experiences. This can negatively impact participation in correctional programs and prison jobs because inmates become discouraged and view the learning experience as challenging and fruitless. Consequently, many incarcerated adults will reintegrate into society after serving their sentences with no increase in their skills (Klein et al., 2004).

Finally, although participation in correctional opportunities is linked to increased literacy and numeracy skills, there is a lack of research on which programs specifically lead to better literacy and numeracy outcomes (Olaghere et al., 2021). Therefore, this current study aims to consider the extent to which different prison programs and activities (e.g., educational, employment, prison activities) may improve incarcerated adults' literacy and numeracy skills. Additionally, this study will investigate demographic differences relating to participation and the extent to which these differences impact skill proficiency.

1.2.2 Engagement in Literacy and Numeracy Activities

Even though education is linked to literacy and numeracy skills, educational attainment without opportunities is insufficient for improving literacy and numeracy skills. Finnie and Meng (2007) found that higher literacy and numeracy proficiencies were associated with higher wages and employment rates even after controlling for years of education among high school dropouts, in the general population. Other studies show that skills are enhanced by practice so that people who engage in more literacy and numeracy practices will demonstrate higher literacy and numeracy outcomes (Bynner & Parsons, 1998; Evans et al., 2017; Reder, 2017; Windisch, 2015).

At the same time, just as engagement increases numeracy and literacy skills (Reder et al., 2020), lack of engagement has detrimental consequences on these skills. People with lower literacy and numeracy proficiencies risk a decline of their skills due to lack of use or lack of engagement in literacy and numeracy activities (Bynner & Parsons, 1998; Cai et al., 2019; Reder et al., 2020). Therefore, it is vital to examine incarcerated adults' literacy and numeracy activities to measure how engagement influences performance in these domains. With an increase in engagement in literacy and numeracy activities, adults are expected to demonstrate higher performance on the assessments.

Lastly, there is a gap in research on whether engagement in literacy and numeracy activities differs among incarcerated adults from diverse backgrounds. Cai et al. (2019) suggested possible differences in the level of engagement in literacy and numeracy activities between incarcerated adults based on race. The authors found that, on average, Black inmates engaged in more literacy activities than White inmates. On the other hand, Hispanic inmates engaged in fewer numeracy skills than white inmates. However, differences in literacy and numeracy performance of incarcerated adults from various racial backgrounds were not examined as related to the level of engagement in literacy and numeracy activities. Therefore, this study will address potential cultural differences pertaining to incarcerated adults' literacy and numeracy skills and their level of engagement in literacy and numeracy activities. This could provide insight into programs inmates from different cultural backgrounds are interested in and whether these programs affect their literacy and numeracy proficiencies.

1.2.3 Utilization of Prison Libraries

Approximately 42% of incarcerated adults utilize library services weekly (Patterson, 2018). Given that prison libraries provide learning opportunities (Lehmann, 2011), it may be informative to examine the learning experience of inmates during incarceration by examining how library use can affect literacy and numeracy performance.

While Patterson (2018) examined how frequently inmates used the library, the effect of library use on literacy and numeracy skills was not examined. Considering that individuals with higher educational attainment and higher literacy and numeracy skills are more likely to engage in more learning opportunities (Grotlüschen et al., 2016; Reder, 2017), inmates with higher educational levels and higher skills might differ in their utilization of prison libraries. Therefore, it is worthwhile to investigate how much performance differs based on library use for adults at varying educational levels.

1.2.4 Time Remaining in Prison

To understand the relationship between engagement and participation in prison programs and literacy and numeracy performance, it is necessary to consider time remaining in prison. Research shows that incarcerated adults with longer sentences participate more in prison programs (Delaney & Smith, 2019). Additionally, Renbarger et al. (2019) also found that incarcerated adults with more time remaining in prison had higher literacy and numeracy skills. However, research is still limited on whether differences are found between participation in prison programs and time remaining in prison based on demographics. On average, males have longer prison sentences than females (Carson, 2020); as a result, males and females could vary in their literacy and numeracy skills based on their time remaining in prison. Therefore, it is necessary to examine the role of time in prison on the literacy and numeracy of inmates from diverse backgrounds.

1.3 Current Study

Given the benefits of higher literacy and numeracy skills to individuals and societies, it is alarming that many incarcerated adults in the United States are not prepared for the demands of modern, information-based economies (Rampey et al., 2016). Although many studies have investigated various factors influencing incarcerated adults' literacy and numeracy skills (Cai et al., 2019; Patterson, 2018; Reder, 2020; Renbarger et al., 2019; Shippen et al., 2010), research is limited on the extent to which individual and prison variables influence inmates' skills and the nature of differences based on gender, age, and race. Therefore, this study aims to examine predictive factors influencing the literacy and numeracy outcomes of incarcerated adults in the U.S. prisons. Specifically, the present study aims to address the following research questions:

1. Background factors: How does educational attainment, parental education, native language status, the number of books at home, health status, and demographics relate to performance on the literacy and numeracy assessments?

2. Malleable prison factors: How do participation in various correctional programs, access to resources, engagement in literacy and numeracy activities, and time remaining in prison relate to performance on the literacy and numeracy assessments? How do these relations differ based on gender, age, and race?

It is hypothesized that higher participation in prison activities and programs will predict performance on literacy and numeracy, above and beyond background factors. Particularly, incarcerated adults who participate in educational and vocational courses will have higher performance on literacy and numeracy outcomes than non-participants. Additionally, incarcerated adults who engage in more literacy and numeracy activities in prison are expected to demonstrate higher skills.

Lastly, differences in factors influencing the literacy and numeracy performance would emerge based on gender, race, and age. Specifically, similar to previous findings, younger incarcerated adults will outperform older incarcerated adults in both literacy and numeracy. Furthermore, incarcerated men and women will demonstrate comparable skills after accounting for the full PIAAC sample and all educational levels. Finally, inmates from various racial background will differ in their skills based on their participation in prison programs and the level of engagement in literacy and numeracy activities while incarcerated.

2 METHOD

2.1 Sample

This study used data from The Program for the International Assessment of Adult Competencies (PIAAC) conducted with the United States prison population. Among 38 participating countries, the U.S. was the only country to include a prison sample. The 2014 PIAAC prison survey data were collected across 98 state and federal prison facilities (Rampey et al., 2016).

The PIAAC survey was initiated and developed by the Organization for Economic Co-operation and Development (OECD) to measure how adults' competencies (i.e., literacy and numeracy competencies) affect various social and economic outcomes (OECD, 2013). In building the PIAAC assessment, many analyses were conducted to ensure the reliability and validity of items and constructs within and across countries (OECD, 2013). Consequently, results from the PIAAC provide empirical evidence on adults' various levels of skills and proficiencies so that population-level interpretations can be made.

2.2 Participants

The PIAAC prison sample included 1,319 incarcerated adults ranging in age from 16-74 years, 80% male, 22% Hispanics, 39% White, 33% Black, and 7% other (Rampey et al., 2016). The analytic sample for this study included 1,247 incarcerated adults who had valid literacy and numeracy scores. Missing data on the predictor variables were deleted listwise in the analyses, which resulted in exclusion of 72 observations from the study.

Table 1 contains weighted means and frequencies based on the final sample (N = 1,247). The majority of inmates were native English speakers (85%) and most had high school or more level of education (71%). Incarcerated adults were predominantly male (93%) with 23%

Hispanic, 34% White, 36% Black, and 7% identifying as Other. Younger incarcerated adults (16-34 years old) represented 48% of the sample. Inmates reported similar rates of father and mother's level of education, with the majority of parents completing a high school level education: 41% of fathers and 44% of mothers completing high school education (see Table 1).

Table 1. Incarcerated Adults' Demographics and Background Characteristics

Demographic Variable	*n*	Weighted Percent
Gender		
Female	249	7
Male	998	93
Race		
Hispanic	263	23
White	483	34
Black	410	36
Other	91	7
Age		
16 - 34	603	52
35 - 74	644	48
Education		
Less than High School	368	29
High School or higher	879	71
Father's Highest Education		
Less than high school	322	26
High school or some college but no degree	511	41
College degree or higher (associate, bachelor, doctorate)	186	15
Don't know	228	18
Mother's Highest Education		
Less than high school	354	28
High school or some college but no degree	551	44
College degree or higher (associate, bachelor, doctorate)	238	19
Don't Know	104	9

Note. Total n = 1,247. Percents were produced using sample weights (Hogan et al., 2016).

2.3 Measures

2.3.1 Background Questionnaire

The PIAAC data provide a wide-ranging background questionnaire (BQ) to help understand and differentiate factors that can influence adults' literacy and numeracy proficiencies, as well as provide an overview of the distribution of proficiencies in the U.S.

(OECD, 2013). The background questionnaire was administered on the computer by trained personnel from the National Center for Education Statistics (NCES) of the U.S. Department of Education (OECD, 2013). Administering the BQ took between 30-40 minutes to complete. The U.S. BQ was the only portion of the PIAAC assessment available in English and Spanish. All other measures (e.g., literacy and numeracy) were administered in English only. This study included information from the BQ on the demographics of incarcerated adults (e.g., gender, race/ethnicity, and age), educational attainment, and health status. Items on parental level of education and number of books at home were also included.

In addition to information on incarcerated adults prior to their incarceration, this study included prison specific questions to reflect factors predicting literacy and numeracy skills during incarceration. These questions included participation in correctional education, prison-job training, prison jobs, job-readiness course, basic skills course, time remaining in prison, and library use. Finally, engagement in literacy and numeracy activities in prison was included.

Following the BQ interview, respondents completed a three-stage CORE assessment. The first stage was a computer-based assessment (CBA) which measured basic skills of participants to use computers. All participants were given the CBA-Stage 1 assessment. Individuals who refused to take the computer assessment were given a paper-based assessment (PBA) instead. Nevertheless, the PIAAC design used IRT scaling procedures to ensure accuracy, reliability, and comparability of the results regardless of the mode of assessment administration.

The CBA-Stage 1 measured basic skills such as clicking, typing, choosing from a pull-down menu, simultaneous clicking and scrolling, dragging and dropping, and highlighting. To pass the CBA-Stage 1 assessment, individuals needed to demonstrate at least knowledge of the first three skills in addition to the highlighting skill. Highlighting was essential because respondents needed to highlight their answers/choices in later literacy and numeracy assessments. Individuals who passed the CBA-Stage 1 assessment continued to take the CBA-Stage 2 assessment. Otherwise, individuals completed the PBA assessment. Both CBA-Stage 2 and PBA assessments assess basic literacy and numeracy skills to screen individuals who qualify to complete the full literacy and numeracy assessments. Participants who passed the CBA-Stage 2 assessment qualified for the computerized literacy and numeracy assessment. Individuals who did not pass the CBA-Stage 2 assessment took the paper-based reading components assessment. On the other hand, participants who passed the PBA assessment qualified to take the paper-based literacy, numeracy, and reading components assessments. Otherwise, individuals completed the paper-based reading components assessment only.

2.3.2 Literacy Assessment

The literacy test represents one's ability to compare, contrast, evaluate, and interpret information, as well as the ability to identify different components of texts to answer questions (PIAAC Literacy Expert Group, 2009). Items on the literacy test include understanding and using information from various sources, such as newspapers, magazines, and websites. For example, some literacy items assess a person's ability to access, identify, and interpret information from a physical exercise chart and determine which muscles are targeted when using different exercise equipment (See example items in Figures 4 and 5 in the appendix).

It is important to note that literacy extends beyond the reading skills needed for written text. The PIAAC enables the measurement of digital literacy, print literacy, and financial literacy. Therefore, literacy items represent a coherent view of literacy skills in daily life. Since participants only complete a subset of the PIAAC literacy items, scores on the literacy test are estimated using item response models as well as imputed values (i.e., plausible values). This statistical technique is aimed at finding the most probable estimates for participants' proficiencies in the literacy domain (Hogan et al., 2016). The literacy proficiency scores are on a 500-point scale (OECD, 2013). For more information on PIAAC literacy proficiency levels, see Table 14 in the appendix.

2.3.3 Numeracy Assessment

The numeracy test represents one's abilities to apply mathematics knowledge and engage in various numeracy/mathematics behaviors in daily life (PIAAC Numeracy Expert Group, 2009). Numeracy items include interpreting and integrating mathematical information when solving various problems. Items may include tables, graphs, maps, or advertisements. For example, some numeracy items assess respondents' abilities to utilize basic numeracy skills (e.g., addition or subtraction) and to determine the temperature on a thermometer given specified units of increase or decrease (See example item in Figure 6 in the appendix). Respondents must use the information provided and their knowledge of mathematics to answer the questions. Therefore, a person's proficiency level is determined by their ability to solve different numeracy problems that rely on their existing knowledge.

Numeracy items reflect arithmetic knowledge and the applied numerate behaviors associated with literacy skills, such as reading and writing. Numerate behaviors are often embedded within larger contexts; therefore, the PIAAC items aim to identify numeracy skills as they occur in social contexts (e.g., work environment) and daily practices. Similar to the literacy assessment, scores on the numeracy test are estimated using item response models as well as imputed values on a 500-point scale (OECD, 2013). For more information on PIAAC numeracy proficiency levels, see Table 15 in the appendix.

2.4 Procedure

Prior to any assessment administration, authorization from federal, state, and other correctional agencies was required. All interviewers completed ethics and prison-specific training to fulfill the requirements for data collection in prison (Hogan et al., 2016). Prior to interview sessions in prison facilities, project negotiators arranged for all authorizations and contact forms to be completed before the interviewer conducted the session to ensure full compliance with testing procedures (Hogan et al., 2016). Lastly, interviews with incarcerated adults were not recorded.

The interviewer completed background questionnaires (BQ) on the laptop regardless of the individual's technical skill level, and the objective of the PIAAC survey was clearly explained to each participant (OECD, 2013). Literacy and numeracy assessment modules included 76 items in each domain and took 60 minutes to administer. However, participants who thought the assessment was challenging and took too long to answer questions had the choice to stop the session. Each participant completed a subset of items, and the difficulty of items within a set increased or decreased based on the participants' proficiency.

Due to the nature of the PIAAC design, various statistical methods were used to estimate adults' proficiencies rather than produce a point estimate of each individual's performance. Each participant had ten plausible values estimating their proficiency in the literacy and numeracy domains (see Hogan et al., 2016). Plausible values are based on a conditional probability distribution that represents participants' proficiency and allows for group comparisons. In order to reduce measurement bias and error and to account for imputation variance, the ten plausible values need to be used (Maehler & Rammstedt, 2020; Rutkowski et al., 2010). Along with the plausible values, the PIAAC data provide sampling weights to ensure accurate estimation by accounting for design-based sampling error. Therefore, this study utilized plausible values and sampling weights to accurately estimate literacy and numeracy proficiencies.

2.5 Study Variables

Literacy and Numeracy skills were the dependent variables in the study. Background and prison factors were the independent variables. Background factors (i.e., demographics, parental education, native language status, number of books at home, health status, and previous educational attainment) were included to examine the extent to which background characteristics influence literacy and numeracy performance. Prison factors in this study included education completed, prison job, vocational courses (i.e., job readiness, life skills, and job training), library use, time remaining in prison, and engagement in literacy and numeracy activities. Prison factors were examined for their direct effects on the outcome variables as well as their interaction effects with demographics (i.e., gender, age, and race) on outcome variables.

2.5.1 Data Preparation

Data preparation was conducted in SAS Version 9.4 following PIAAC data management recommendations (Yamashita et al., 2021). All categorical predictors were dummy coded prior to running analyses. Table 2 shows the original PIAAC variables and the recoding of predictor variables (i.e., background and prison predictors).

Table 2. Variable Recoding

PIAAC Variable	PIAAC Coding	Variable Rename	Variable Recoding	Notes
GENDER_R	Male = 1 Female = 2	Female	Male = 0 Female = 1	
AGE1634	35-74 = 0 16-34 = 1	Youth		
RACETHN_4CAT	Hispanic = 1 White = 2 Black = 3 Other race = 6 Not stated or inferred = N	Hispanic White Black	Hispanic: Yes=1, No=0 White: Yes=1, No=0 Black: Yes=1, No=0	Collapsed not stated and other race together. Other race is the reference category.
NATIVESPEAKER	Yes = 1 No = 2	Native	Yes = 1 No = 0	

B_Q01AUS_C	1 = Less than HS 2 = HS/some college but no degree 3 = College degree or higher	LessthanHS	0 = HS or more 1 = Less than HS	Collapsed HS and more than HS together. The more than HS category has only 85 observations.
J_Q07BUS	1 = Less than HS 2 = HS/some college but no degree 3 = College degree or higher D = Don't Know	Father Education	Less: Yes=1, No=0 HS: Yes = 1, No=0 More: Yes=1, No=0	DK is the reference category.
J_Q06BUS	1 = Less than HS 2 = HS/some college but no degree 3 = College degree or higher D = Don't Know	Mother Education	LHS: Yes=1, No=0 HS: Yes = 1, No=0 MHS: Yes=1, No=0	DK is the reference category.
J_Q08	1 = 10 books or less 2 = 11 to 25 books 3 = 26 to 100 books 4 = 101 to 200 books 5 = 201 to 500 books 6 = More than 500 books	Number of Books at Home	≤10: Yes=1, No=0 11-25: Yes=1, No=0 26-100: Yes=1, No=0	Collapsed the last three categories (i.e., categories 4, 5, & 6) due to the low number of observations. Reference category is more than 100.
P_Q120	1 = Grades 1-6 2 = Grades 7-9 3 = HS or GED 5 = Pre-associate or trade school (no degree or certificate received) 6 = College or trade school certificate 7 = Associate degree 8 = Bachelor's 9 = Master's 10 = Professional degree 11 = Doctorate degree 12 = no further education	Prison Education (Completed)	LHS: Yes=1, No=0 HS: Yes = 1, No=0 MHS: Yes=1, No=0	Collapsed categories with more than HS education into one category. Collapsed categories of less than HS into one category. Reference category is "no further education".
P_Q190A	Yes = 1 No = 2	Job Readiness	Yes = 1 No = 0	
P_Q190C	Yes = 1 No = 2	Life Skills	Yes = 1 No = 0	

P_Q220	Yes = 1 No = 2	Job Training	Yes = 1 No = 0	
P_Q390	Yes = 1 No = 2	Prison Job	Yes = 1 No = 0	
I_Q08	1 = Excellent 2 = Very Good 3 = Good 4 = Fair 5 = Poor	Health Status	1 = Poor 2 = Fair 3 = Good 4 = Very Good 5 = Excellent	Reverse coded.
P_Q180	1 = less than 6 months 2 = 6-12 months 3 = 1-2 years 4 = more than 2 years 5 = 2-5 years 6 = more than 5 years 7 = never	Time Remaining in Prison	< 6 months: Yes=1, No=0 6-12 months: Yes=1, No=0 1-2 years: Yes=1, No=0 2-5 years: Yes=1, No=0 > 5 years: Yes=1, No=0	Collapsed categories 4 and 5 because the categories overlap. The reference category is “Never”.
P_Q370	1 = Daily 2 = Weekly 3 = Monthly 4 = Once or Twice a year 5 = Never V = Valid Skip	Library Use	Daily: Yes=1, No=0 Weekly: Yes=1, No=0) Monthly: Yes=1, No=0 Annually: Yes=1, No=0 Never: Yes=1, No=0	Collapsed never and valid skips. The reference category is “Daily”.
WRITHOMEUSP_WLE_CA	0 = all zero responses 1 = lowest to 20% 2 = more than 20% to 40% 3 = more than 40 % to 60% 4 = more than 60% to 80% 5 = more than 80%	Writing Engagement		Index of writing skills use in everyday life in prison. Derived from categorical variable on how often adults use writing skills in prison.
READHOMEUSP_WLE_CA	0 = all zero responses 1 = lowest to 20% 2 = more than 20% to 40% 3 = more than 40 % to 60% 4 = more than 60% to 80% 5 = more than 80%	Reading Engagement		Index of reading skills use in everyday life in prison. Derived from categorical variable on how often adults use reading skills in prison.
NUMHOMEUSP_WLE_CA	0 = all zero responses 1 = lowest to 20% 2 = more than 20% to 40% 3 = more than 40 % to 60%	Numeracy Engagement		Index of numeracy skills use in everyday life in prison. Derived from categorical variable on how often adults use

	4 = more than 60% to 80% 5 = more than 80%		numeracy skills in prison.

2.5.2 Data Analytic Plan

In order to obtain valid results and inferences, the model must account for the complex design of the PIAAC sample (Hogan et al., 2016). Therefore, analyses were conducted using Mplus8 software (Múthen & Múthen, 1998-2022). Mplus has been shown to accommodate the PIAAC multistage design features and to allow for accurate analyses by accounting for sample weights, plausible values, and missing data (Maehler & Rammstedt, 2020; Yamashita et al., 2021). Additionally, path analysis was used to examine the relations between the variables. The advantages of path analysis include evaluating the relationships between the independent and dependent variables simultaneously, allowing for graphing the relations between variables, and accounting for error terms in the model (Jeon, 2015).

Three path models were conducted to examine the relations between the literacy and numeracy outcomes and the independent variables. The first model included background factors of literacy and numeracy skills. The second model included background and prison-specific factors. Finally, the third model included background, prison, and interaction factors. The purpose of this sequential design was to check the stability of the coefficients and to evaluate the sensitivity of the models as more variables were added.

Each model included ten plausible values, as well as the final sampling weight and 80 replicate weights. Standardized and unstandardized results are provided in model results. However, all interpretations of the results are based on the unstandardized estimates to allow for easier interpretation for predictor variables.

3 RESULTS

Even though path models for literacy and numeracy were jointly fit in Mplus, the results from the models are analyzed separately with respect to the outcome variable in order to distinguish factors that are uniquely predictive of each of the dependent variables.

3.1 Model 1

3.1.1 Literacy

Age was a statistically significant predictor of literacy. Results showed that compared to older incarcerated adults, younger incarcerated adults demonstrated 0.09 units higher literacy performance, on average, when controlling for all other predictors (b[1] = 0.09, p <.05, 95% CI [0.04, 0.14][2]). Furthermore, compared to incarcerated adults who did not disclose their race/ethnicity, only incarcerated adults identifying as Black showed a significant difference in their literacy skills (b = -0.13, p = .04, [-0.25, 0.00]). On average, Black incarcerated adults demonstrated 0.13 units lower literacy performance, controlling for all other predictors. Gender was not a significant predictor of literacy skills (b = -0.06, p = .08, [-0.12, 0.01]).

Native language status was a significant predictor of literacy performance. On average, incarcerated adults who were native English speakers demonstrated 0.19 units increase in their literacy performance compared to incarcerated adults who reported non-native English status (b = 0.19, p <.05, [0.07, 0.31]).

Health status was a significant predictor of literacy skills. On average, higher levels of self-rated health status was associated with 0.03 units increase in literacy performance (b = 0.03, p = .01, [0.01, 0.05]).

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[1] Model results are based on path analysis models. ‘b’ is used to represent the conventional unstandardized regression coefficient.

[2] Square brackets are used to indicate the 95% confidence interval.

The number of books at home was a significant predictor of literacy performance. Incarcerated adults who reported having less than ten books at home or having between 11-25 books at home showed significantly lower literacy performance compared to incarcerated adults who had more than 100 books at home ($b = -0.13$, $p < .05$, [-0.22, -0.05] and $b = -0.19$, $p < .05$, [-0.29, -0.09] respectively).

Incarcerated adults' level of educational attainment had a significant influence on their literacy skills. Compared to incarcerated adults who completed high school or more before incarceration, inmates with less than high school education showed .29 units decrease in their literacy performance, controlling for all other predictors ($b = -0.29$, $p <.05$, [-0.36, -0.21]).

3.1.2 Numeracy

For the numeracy outcome, age was a significant predictor of performance. Results from Model 1 showed that compared to older incarcerated adults, younger incarcerated adults demonstrated 0.12 units higher numeracy performance, on average ($b = 0.12$, $p <.05$, [0.06, 0.17]). Additionally, compared to incarcerated adults who identified as Other, incarcerated adults identifying as Black showed a significant difference in their numeracy skills. On average, Black incarcerated adults performed lower on numeracy, controlling for all other predictors ($b = -0.19$, $p = .03$, [-0.36, -0.02]). Gender was also a significant predictor of numeracy skills. On average, females showed a 0.10-unit decrease in numeracy performance in comparison to males ($b = -0.10$, $p <.05$, [-0.16, -0.04]).

Native language status was a significant predictor of numeracy performance. On average, incarcerated adults who were native English speakers showed higher numeracy performance by 0.24 units compared to incarcerated adults who reported non-native English status ($b = 0.24$, $p <.05$, [0.12, 0.36]). Additionally, health status was a significant predictor of numeracy. On average, as self-rated health status improved, numeracy performance increased by 0.04 units ($b = 0.04$, $p < .05$, [0.01, 0.07]). Finally, the number of books at home significantly predicted numeracy performance only for incarcerated adults who reported having 11-25 books. Compared to incarcerated adults with more than 100 books at home, incarcerated adults who had between 11-25 books at home showed significantly lower numeracy performance ($b = -0.16$, $p = .01$, [-0.27, -0.05]).

Educational attainment prior to incarceration had a significant influence on their numeracy skills. Compared to incarcerated adults with high school or more levels of education, inmates with less than high school education showed lower numeracy performance ($b = -0.39$, $p < .05$, [-0.47, -0.31]).

3.2 Model 2

3.2.1 Literacy

Model 2 included all predictors from Model 1, as well as prison-specific predictors. Related to background factors, Model 2 showed similar results to Model 1. Additionally, the magnitude and the direction of the influence of the predictors remained comparable. Furthermore, differences in literacy performance for Black adults were no longer significant when prison factors were added to the model ($b = -0.11$, $p = .07$, [-0.24, 0.01]). Finally, health status was no longer a significant predictor of literacy performance ($b = 0.02$, $p = .05$, [0.00, 0.05]).

Among the prison-specific factors, the level of education completed in prison was only significant for incarcerated adults who completed more than high school level of education in prison. In comparison to incarcerated adults who did not complete further education in prison, incarcerated adults who completed more than high school education in prison showed 0.15 units higher literacy skills, on average, controlling for all other predictors ($b = 0.15$, $p < .05$, [0.07, 0.22]).

Engagement in literacy activities (i.e., reading and writing) was not a significant predictor of literacy performance. However, higher engagement in numeracy activities was significantly associated with higher literacy performance. Specifically, results showed an average of 0.02-unit increase in literacy performance per unit increase in numeracy engagement ($b = 0.02$, $p = .01$, [0.00, 0.03]).

For library use, only incarcerated adults who used the library monthly compared to daily showed a significant increase in their literacy performance ($b = 0.11$, $p = .02$, [0.02, 0.19]).

Time remaining in prison was a significant predictor of literacy skills. Compared to incarcerated adults who answered “never” to being released from prison, adults with shorter prison sentences showed lower literacy performance. Inmates who had the shortest time remaining in prison showed the lowest literacy performance ($b = -0.24$, $p <.05$, [-0.37, -0.11]), followed by incarcerated adults who have 6 to 12 months remaining in prison ($b = -0.19$, $p =.01$, [-0.32, -0.05]). Incarcerated adults with 1-2 years or 2-5 years showed a similar level of reduction in their literacy performance ($b = -0.16$, $p = .02$, [-0.29, -0.03] and $b = -0.16$, $p = .02$, [-0.27, -0.04], respectively). Finally, inmates who had more than five years until their release from prison showed .17 units lower literacy performance ($b = 0.17$, $p =.01$, [-0.30, -0.05]).

3.2.2 Numeracy

Related to background predictors, Model 2 showed similar results to Model 1. The significant predictors identified in Model 1 maintained their significance in Model 2, with similar magnitudes and directions of influence.

Among the prison-specific factors, the level of education completed in prison was a significant predictor of numeracy when incarcerated adults reported completing more than high school education in prison. In comparison to incarcerated adults who did not complete further education in prison, incarcerated adults who completed more than high school education in prison showed significantly higher numeracy performance (b = 0.18, p < .05, [0.09, 0.27]).

Library use was also a significant predictor of numeracy. Results showed that compared to incarcerated adults who used the library daily, incarcerated adults who used the library monthly or annually had an average of 0.15 (monthly) and 0.16 (annually) units higher in their numeracy performance (monthly: b = 0.15, p = 0.02, [0.03, 0.27]; annually: b = 0.16, p = 0.03, [0.01, 0.30]).

Finally, on average, one unit increase in engagement in numeracy activities in prison was associated with a 0.02 change in performance (b = 0.02, p = .01, [0.01, 0.04]).

3.3 Model 3

3.3.1 Literacy

In contrast to the results from Models 1 and 2 results for background factors, age did not remain a significant predictor of literacy performance (b = 0.14, p = .24, [-0.09, 0.37]). Only native language status, less than high school educational attainment, and the number of books at home remained statistically significant background factors.

Prison-specific factors that were significant predictors of literacy in Model 2 remained significant in Model 3 (i.e., prison education (more than high school), monthly library use, and time remaining in prison). Additionally, the strength of their influence on the literacy outcome remained comparable to results from Model 2.

Finally, while the main effect of engagement in numeracy activities in prison was no longer a significant predictor of literacy in Model 3, the effect of engagement in numeracy activities differed among incarcerated adults from different racial backgrounds. Specifically, incarcerated adults who identified as Black showed 0.09-units higher literacy performance when engaging in more numeracy activities in prison than adults who identified as Others ($b = 0.09$, $p = .02$, [0.02, 0.16]).

3.3.2 Numeracy

In model 3, the main effects of demographics on the numeracy outcome were not statistically after interaction terms were entered into the model. Additionally, the main and interaction effects of health status were not associated with significant differences in numeracy performance.

Native language status, the number of books at home, and inmate's level of educational attainment were strong predictors of numeracy performance. Incarcerated adults who were native English speakers scored significantly higher on numeracy than inmates who were non-native English speakers ($b = 0.26$, $p < .05$, [0.13, 0.38]). Furthermore, results for the number of books at home remained the same as Model 2. Incarcerated adults with 11-25 books at home performed 0.13 units lower on numeracy than inmates with more than 100 books at home ($b = -0.13$, $p = .01$, [-0.24, -0.03]). Lastly, incarcerated adults who entered prison with less than a high school education showed 0.37 units decrease in their numeracy performance compared to inmates entering prison with high school or more education ($b = -0.37$, $p < .05$, [-0.46, -0.28]).

Among prison-specific factors, library use, job-training, and time remaining in prison were associated with statistically significant differences in numeracy performance. Library use remained positively related to higher performance on numeracy for incarcerated adults who used the library monthly or annually (monthly: $b = 0.15$, $p = 0.02$, [0.02, 0.27]; annually: $b = 0.16$, $p = 0.03$, [0.02, 0.31]).

The main effect of job training was a significant predictor of numeracy skills. Compared to inmates who did not attend job training classes, inmates who attended classes scored significantly higher in their numeracy performance ($b = 0.27$, $p = .04$, [0.02, 0.54]). Furthermore, the interaction of job training with racial background was significant on numeracy performance. Incarcerated adults who reported participating in prison job training scored lower on numeracy than adults identified as Others (White: $b = -0.28$, $p = .04$, [-0.55, -0.02]; Black: $b = -0.28$, $p = .04$, [-0.54, -0.02]; Hispanic: $b = -0.34$, $p = .01$, [-0.59, -0.10]).

The level of education completed in prison remained a significant predictor of numeracy, controlling for all other predictors in the model. Compared to incarcerated adults who did not complete further education in prison, incarcerated adults who completed more than high school education in prison showed an average of 0.19-unit increase in their numeracy performance ($b = 0.18$, $p < .05$, [0.10, 0.28]).

While the main effect of engagement in numeracy activities was no longer significant, the interaction effect showed differences in performance among inmates from different racial backgrounds. Incarcerated adults who identified as White showed an average of 0.09-unit higher numeracy performance when engaging in more numeracy activities in prison than adults identifying as Others ($b = 0.09$, $p = .04$, [0.01, 0.17]).

Finally, time remaining in prison was only significant for incarcerated adults who had less than six months until their release. In this category, inmates who had less than six months prison sentence scored significantly lower on numeracy than inmates with life-long sentences ($b = -0.15$, $p = .03$, [-0.29, -0.01]).

4 DISCUSSION

Concerning the demographic characteristics examined, results from the literacy models showed no significant main effects of gender. Incarcerated women and men performed comparably on the literacy outcome after controlling for all other predictors. However, incarcerated women performed significantly lower on numeracy than incarcerated men. These results differ from previous research by Patterson (2018). The author found no gender differences in either literacy and numeracy performance for incarcerated adults with less than a high school education. In contrast, the results of this study suggest that there may be differences in numeracy skills based on gender, particularly when considering the entire sample of participants in the PIAAC prison survey. However, differences in literacy and numeracy performance based on gender across each the levels of educational attainment were not examined in this study. Therefore, more research is needed to further examine the extent to which the levels of educational attainment influence the numeracy skills of incarcerated men and women.

The age of incarcerated adults was associated with statistically significant differences in literacy and numeracy performance but only in the background and prison factors models. On average, younger incarcerated adults had higher literacy and numeracy scores than older incarcerated adults. This finding is consistent with results from previous research on the effects of age on the literacy and numeracy skills of incarcerated adults (Renbarger et al., 2019). Nevertheless, in this study, the main effect of age was no longer significant when interactions were entered into the literacy and numeracy models. Therefore, results suggest that the relation between age and literacy and numeracy performance might depend on other variables in the model. Alternatively, results might be an artifact of the categorization of the age variable. In this study, we divided age into two groups, distinguishing between younger and older incarcerated adults. However, given the nature of the survey, a continuous variable for age was not available in order to maintain the confidentiality of participants (OECD, 2013).

Lastly, statistically significant differential effects of race on literacy and numeracy performance were found but only for Black incarcerated adults. Results showed that inmates who identified as Black demonstrated lower literacy and numeracy performance than incarcerated adults who identified as Other. However, the main effect for Black incarcerated adults was not consistently significant across the literacy and numeracy models. These findings suggest that Black incarcerated adults might be at a disadvantage to improve their literacy and numeracy skills in prison (Olaghere et al., 2021). Additional research is needed to further explore the inequities and disparities for incarcerated adults from minoritized backgrounds.

Among background factors, native language status was a strong positive predictor of literacy and numeracy performance after controlling for all other variables. Native English speakers demonstrated higher literacy and numeracy performance than non-native speakers, aligning with prior research findings (Olaghere et al., 2021). Additionally, the number of books at home was an important predictor for literacy and numeracy outcomes, similar to findings on the influence of library sizes on literacy and numeracy skills of adults in the general population (Sikora et al., 2019). Results showed that incarcerated adults with less than 26 books at home score significantly lower in numeracy and literacy than adults with more than 100 books at home.

Health status was not associated with statistically significant changes in literacy and numeracy skills of prisoners. Specifically, while incarcerated women report poorer health conditions (Patterson, 2018), there were no significant differences in literacy and numeracy performance of incarcerated men and women based on their health status. Additionally, there was no significant differential effect of health status on performance based on age or race.

Based on findings from the general population, literacy and numeracy skills of emerging adults are influenced by their parental education (Finnie & Meng, 2007). However, results from this study showed no substantial differences in incarcerated adults' skills related to their parental education. Nevertheless, the impact of inmates' educational attainment before incarceration appears to be one of the most consistent and positive predictors influencing the skills of incarcerated adults. Similar to findings from Renbarger et al. (2019), incarcerated adults who completed high school or beyond before their incarceration exhibited higher performance on the literacy and numeracy assessments than individuals with less than a high school education. Additionally, this study found that the level of education completed in prison was associated with higher literacy and numeracy performance, but the effect was dependent on the level of education completed. Only incarcerated adults who completed more than a high school education had higher literacy and numeracy scores. This suggests that although inmates may complete higher levels of education during their incarceration, completing high school or less may not be sufficient to substantially affect their skill development.

Results of this study showed that prison job training was a statistically significant predictor of numeracy skills. Incarcerated adults who participated in job training scored higher on numeracy than non-participants, on average, which is consistent with previous findings from Cai et al. (2019). However, this study also found that the effect of job training depends on the racial background of incarcerated adults. Compared to inmates who identified as Other and participated in prison job training, White, Black, and Hispanic inmates who participated in prison job training scored lower on numeracy, on average.

Nevertheless, participation in other prison programs (i.e., prison job, basic skills courses, or job readiness courses) was not associated with higher literacy or numeracy skills. One possible explanation for these results is that only 36% of incarcerated adults participate in prison programs (Rampey et al., 2016). Furthermore, Patterson (2018) showed that incarcerated adults often do not find relevance in prison programs, which might contribute to the low participation rates. Given the nature of the sample, it might also be possible that the type of crime or duration of prison sentence play a role in inmates' participation. However, the reasons for the lack of participation were not explored in this study. More research is needed to investigate how inmates' motivation or institutional barriers influence their skill outcomes.

Results showed that higher engagement in numeracy activities had a statistically significant main effect on the literacy outcome. Incarcerated adults who engaged in more numeracy activities in prison demonstrated higher performance in literacy. Additionally, the effect of engagement in numeracy activities depended on the respondents' racial background. Incarcerated adults identifying as Black and engaging in more numeracy activities in prison scored significantly higher on literacy than Others. While the interaction effects for White and Hispanic inmates were not statistically significant, the results showed an overall positive relation between higher engagement in numeracy and higher numeracy performance. Studies on engagement practices suggest that oftentimes short-term changes in proficiencies are not observed; however, positive performance changes are more likely to occur over a longer period of time (Reder et al., 2020). Therefore, it is possible that incarcerated adults who continue to engage in higher numeracy activities in prison could continue to improve their skills overtime.

Furthermore, engagement in numeracy activities was also a positive predictor of numeracy performance, and the effect for this predictor differed based on race. Interaction effects showed that White inmates with higher engagement in numeracy activities scored higher on numeracy than inmates who identified as Other. However, there were no statistically significant differences in numeracy performance for inmates identifying as Black or Hispanic. Nonetheless, similar to the literacy outcome, the interaction effects for all racial groups were positively related to numeracy performance when incarcerated adults engaged in more numeracy activities. Therefore, more research focusing on the influence of numeracy engagement on numeracy proficiencies over time may help to clarify the nature of engagement effects.

In contrast, results from this study showed that engagement in literacy activities in prison was not associated with higher scores on the literacy or numeracy assessments, and there were no statistically significant differences based on race. Noteworthy, the results showed that the relation between literacy engagement among incarcerated adults from diverse racial backgrounds differed based on the type of literacy activity. Specifically, higher engagement in writing activities was associated with positive performance on the literacy and numeracy outcomes, overall. On the other hand, higher engagement in reading activities showed negative relations for all racial groups as related to the literacy outcome. However, higher engagement in reading activities was negatively associated with numeracy performance but only for White inmates, compared to positive interaction effects for Black and Hispanic inmates. These findings suggest that the extent to which engagement in literacy activities in prison influence performance differs among incarcerated adults from diverse racial backgrounds. More importantly, the effect seems to differ based on the type of literacy activity that inmates participate in (i.e., reading or writing). Therefore, the type of engagement activities that inmates choose to partake in while incarcerated has a greater influence on their skills, above and beyond their background factors.

Library use was a significant predictor of literacy and numeracy skills. However, the effect was only statistically significant for incarcerated adults who used the library monthly compared to adults who reported using the library services daily. This finding suggests that using the library services daily does not significantly improve the literacy skills of inmates. However, the PIAAC does not provide information on the types of programs offered in prison libraries, nor on the nature and quality of library use (i.e., what inmates may have been using the library for). As a result, it was not feasible to conduct further examinations of the effects of library use on the literacy and numeracy skills of incarcerated adults in the current project.

Finally, time remaining in prison was found to have differing effects on the literacy and numeracy skills of incarcerated adults. Results showed that incarcerated adults with more time remaining in prison scored higher on literacy than adults with less time remaining at all levels. This could be because incarcerated adults who have longer sentences were more likely to participate in more learning opportunities and training during their incarceration than adults with shorter sentences (Delaney & Smith, 2019; Reder, 2020).

In contrast, results for the numeracy outcome showed that time remaining in prison only had a statistically significant effect for incarcerated adults who had less than six months left in prison. This finding suggests that while time remaining in prison influences numeracy skills, the effects are only evidenced at the extreme levels of time remaining in prison (i.e., less than six months versus a life-long sentence). Inmates who have longer sentences might choose to participate in various programs that potentially help improve their skills over time. However, more research is required to reliably determine the relation between time remaining in prison and the numeracy skills of incarcerated adults. Additionally, further research is needed on the influence of length of prison sentences on the literacy and numeracy performance. Time served in prison was not accounted for in this study. Even though the PIAAC data provide information about the length of time remaining to be released from prison, data on the full sentence length are not available. Thus, accounting for the complete length of prison sentence (i.e., time served and time remaining) might help further clarify the role of time in prison on the literacy and numeracy performance of incarcerated adults.

4.1 Limitations

In addition to the caveats and limitations mentioned above, there are further limitations to consider for the present study. While the PIAAC provides data on incarcerated adults prior to their incarceration and during their incarceration, the survey design is cross-sectional and retrospective rather than longitudinal. As a result, incarcerated adults' performance over time could not be examined. In addition, given the nature of the PIAAC's design, only population-level estimates were examined. Individuals might differ in important ways; nevertheless, individual-level estimates could not be investigated.

In order to make population-level inferences, the PIAAC oversampled from female prisons to obtain a representative sample of females in the incarcerated population. Nonetheless, examining the effects of gender interactions with all background and prison factors was not feasible. The cell sizes became smaller in such grouping the data, which resulted in loss of statistical power to consider all interactions. Although the current analysis follows the design-based weighting for population level estimates, multiple-group modeling of genders separately or multilevel modeling of prisoners within institutions could provide different and informative results.

It is important to note that the current set of models were strictly predictions to the chosen outcomes of numeracy and literacy. Beyond the interactions considered here, variables could relate to each other in complex ways. Background factors could predict prison factors. Such alternative predictive structures and possible nonlinear relations were not considered here.

Finally, programs can provide opportunities for practicing literacy and numeracy skills (Vera-Toscano et al., 2017). For instance, contrary to expectations, results showed that library use was positively associated with higher literacy and numeracy skills for incarcerated adults using the library less frequently than those who used the library services daily. However, the type of programs and activities that incarcerated adults used the library for were not identified in the PIAAC. Moreover, the nature or library use was not recorded—it is possible that some inmates used the library for serious study while others may have used it more recreationally or to escape other areas of the prison. Therefore, more research on the reasons inmates access library services and the type of programs they attend in prison libraries would help elucidate these performance differences. Additionally, many prison programs and activities in this study did not have a significant effect on performance. Without the ability to thoroughly examine the quality and availability of prison programs across prisons, factors influencing performance could not be adequately evaluated. The present estimates assume all programs are essentially equal across institutions.

4.2 Implications and Future Directions

Although this study's findings may be disheartening regarding the effectiveness of prison programs on incarcerated adults' literacy and numeracy skills, they are informative and emphasize the need for more research and action to address these issues. The findings from this study are informative to policymakers and stakeholders because they provide empirical data on the extent to which prison programs and activities may influence the literacy and numeracy performance of inmates from diverse backgrounds. For instance, higher engagement in numeracy activities was positively associated with higher literacy skills for Black inmates while higher engagement in numeracy activities was positively associated with higher numeracy skills for White inmates. Therefore, investment in prison programs may help improve incarcerated adults' literacy and numeracy skills. Specifically, investing in skill-building initiatives in prisons helps prepare incarcerated adults reintegrate into society successfully and enhances their employment prospects (Cai et al., 2019). With increased skills, incarcerated adults could support themselves and their families and engage more in their communities.

Additionally, investing in inmates' outcomes can help reduce recidivism and increase safety in societies (Galeshi & Bolin, 2022). Incarcerated adults with higher skills are less likely to engage in criminal activities and are less likely to recidivate (Steurer, 2020). Unfortunately, findings from this study suggest that participation in prison programs did not substantially predict higher literacy and numeracy skills of incarcerated adults. Therefore, allocating resources toward programs that improve incarcerated adults' competencies not only prepares inmates to contribute positively to societies but also helps reduce recidivism costs by millions of dollars for each state in the U.S. (Steurer & Smith, 2003).

Finally, the PIAAC survey includes variables with different scales, such as categorical, ordinal, and continuous, which might have influenced the results of the analyses. Although we did some background checking on different scaling (not reported here), the relations between these predictors and the outcomes may differ by choice of scales. However, this study did not evaluate whether variable scaling had an influence on the literacy and numeracy outcomes. Thus, the future direction for this research is to further disentangle the underlying effects of prison-specific factors on literacy and numeracy skills while considering the role of variable scaling on the outcomes. For instance, there were differential effects of engagement variables (i.e., engagement in reading, writing, and numeracy activities) for incarcerated adults based on race/ethnicity. However, the engagement variables used in this study were ordinal rather than categorical variables; thus, the variables were treated as continuous variables in the analyses. The ordinal variable for engagement in literacy/numeracy activities provides an overall percentage of skill use in literacy or numeracy activities during incarceration. On the other hand, the categorical variable provides information on how frequently each literacy or numeracy skill was used in prison (e.g., how often do you use a calculator in prison: 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, and every day). Therefore, next steps include evaluating whether similar effects are found when categorical engagement variables are entered into the model and whether these effects differ among inmates based on demographics. This would allow for an evaluation of how frequently incarcerated adults engage in certain literacy and numeracy activities and whether activities differ in their influence on performance.

Furthermore, results from this study showed that incarcerated adults with the lowest skills were the ones who used the library most frequently (i.e., using the library daily). However, this study did not examine individual profiles of incarcerated adults. Research shows many prisoners might have undiagnosed learning difficulties or impairments (Koo, 2016). Therefore, future projects may benefit from examining the literacy and numeracy skills of incarcerated adults who report learning impairments or difficulties and whether different programs have differential effects on their literacy and numeracy skills.

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6 TABLES

Table 3. Sample Frequencies and Descriptive Statistics

Variable	*N*	Weighted Percent
English Native Language		
Yes	1080	15.08
No	167	84.92
Number of Books at Home		
10 books or less	435	36.17
11-25 books	270	21.61
26-100 books	340	26.57
101 books or more	202	15.65
Prison Education Completed		
Less than high school diploma	91	7.97
High school diploma or some college but no degree	248	20.82
College degree or higher (associate, bachelor, doctorate)	169	13.42
No further education	739	57.79
Prison Job		
Yes	756	61.19
No	491	38.81
Job Readiness Classes		
Yes	315	24.95
No	932	75.05
Job Training Classes		
Yes	290	77.30
No	957	22.70
Basic Life-Skills Classes		
Yes	410	32.30
No	837	67.70
Library Use		
Daily	84	6.75
Weekly	477	36.26
Monthly	226	18.08
Annually or Bi-annually	120	10.17
Never	340	28.74
Time Remaining in Prison		
Less than 6 months	264	18.70
6-12 months	207	16.02
1-2 years	239	19.25
2-5 years	238	19.58
More than 5 years	238	20.97
Never	61	5.48

Note. (*N* = 1,247)

Variable	*N*	Weighted Means
Health Status Rating (Ordinal)	1247	3.54
Engagement in Literacy (Reading)	1247	3.11
Engagement in Literacy (Writing)	1247	2.61
Engagement in Numeracy	1247	2.42

Table 4. Literacy Model 1 - Main Effects of Background Factors

Literacy Predictors	b	S.E.	*p*	95% CI LB	95% CI UB	*b
Youth	0.09	0.03	0.00	0.04	0.14	0.10
Female	-0.06	0.03	0.08	-0.12	0.01	-0.03
White	0.09	0.07	0.16	-0.04	0.22	0.10
Black	-0.13	0.06	0.04	-0.25	0.00	-0.13
Hispanic	0.03	0.08	0.74	-0.12	0.18	0.02
Native Speaker	0.19	0.06	0.00	0.07	0.31	0.15
Health Status	0.03	0.01	0.01	0.01	0.05	0.07
Education (LHS)	-0.29	0.04	0.00	-0.36	-0.21	-0.28
Father Education (LHS)	-0.05	0.05	0.28	-0.15	0.04	-0.05
Father Education (HS)	-0.02	0.04	0.72	-0.10	0.07	-0.02
Father Education (MHS)	-0.01	0.07	0.92	-0.14	0.12	-0.01
Mother Education (LHS)	0.01	0.05	0.88	-0.09	0.11	0.01
Mother Education (HS)	0.06	0.05	0.28	-0.05	0.16	0.06
Mother Education (MHS)	0.07	0.07	0.31	-0.06	0.20	0.06
Books (10 or less)	-0.13	0.04	0.00	-0.22	-0.05	-0.14
Books (11-25)	-0.19	0.05	0.00	-0.29	-0.09	-0.17
Books (26-100)	-0.04	0.04	0.38	-0.12	0.05	-0.04
Literacy Intercept	2.37	0.11	0.00	2.16	2.59	5.13
Literacy Residual Variance	0.16	0.01	0.00	0.14	0.19	0.77
Literacy R-Square	0.23	0.03	0.00	—	—	—

Note. HS = high school. LHS = less than high school. MHS = more than high school. *b = Standardized Coefficients. LU: Lower Bound of the 95% confidence interval. UB: Upper Bound of the 95% confidence interval.

Table 5. Numeracy Model 1 - Main Effects of Background Factors

Numeracy Predictors	b	S.E.	*p*	95% CI LU	95% CI UB	*b
Youth	0.12	0.03	0.00	0.06	0.17	0.11
Female	-0.10	0.03	0.00	-0.16	-0.04	-0.05
White	0.15	0.09	0.10	-0.03	0.32	0.13
Black	-0.19	0.09	0.03	-0.36	-0.02	-0.17
Hispanic	0.05	0.10	0.64	-0.14	0.23	0.04
Native Speaker	0.24	0.06	0.00	0.12	0.36	0.16
Health Status	0.04	0.01	0.00	0.01	0.07	0.09
Education (LHS)	-0.39	0.04	0.00	-0.47	-0.31	-0.33
Father Education (LHS)	-0.08	0.05	0.14	-0.19	0.03	-0.07
Father Education (HS)	-0.04	0.05	0.44	-0.14	0.06	-0.04
Father Education (MHS)	0.01	0.07	0.85	-0.12	0.15	0.01
Mother Education (LHS)	0.07	0.07	0.29	-0.06	0.21	0.06
Mother Education (HS)	0.11	0.07	0.12	-0.03	0.24	0.10
Mother Education (MHS)	0.10	0.08	0.20	-0.06	0.26	0.08
Books (10 or less)	-0.10	0.05	0.05	-0.19	0.00	-0.09
Books (11-25)	-0.16	0.06	0.01	-0.27	-0.05	-0.12
Books (26-100)	-0.02	0.06	0.78	-0.12	0.09	-0.01
Numeracy Intercept	1.96	0.12	0.00	1.72	2.20	3.64
Numeracy Residual Variance	0.21	0.01	0.00	0.18	0.23	0.71
Numeracy R-Square	0.29	0.03	0.00	—	—	—
Literacy with Numeracy						
Residual Covariance	0.14	0.01	0.00	0.12	0.16	—
Correlation	0.76	0.02	0.00	0.73	0.79	—

Note. HS = high school. LHS = less than high school. MHS = more than high school. *b = Standardized Coefficients. LU: Lower Bound of the 95% confidence interval. UB: Upper Bound of the 95% confidence interval.

Table 6. Literacy Model 2 - Main Effects of Background & Prison Factors

Literacy Predictors	b	S.E.	*p*	95% CI LU	95% CI UB	*b
Youth	0.11	0.03	0.00	0.06	0.17	0.12
Female	-0.05	0.04	0.16	-0.12	0.02	-0.03
White	0.09	0.07	0.18	-0.04	0.22	0.09
Black	-0.11	0.06	0.07	-0.24	0.01	-0.12
Hispanic	0.02	0.08	0.80	-0.13	0.17	0.02
Native Speaker	0.19	0.06	0.00	0.07	0.31	0.15
Health Status	0.02	0.01	0.05	0.00	0.05	0.06
Education (LHS)	-0.26	0.05	0.00	-0.35	-0.17	-0.26
Father Education (LHS)	-0.04	0.05	0.38	-0.13	0.05	-0.04
Father Education (HS)	-0.01	0.04	0.85	-0.09	0.07	-0.01
Father Education (MHS)	-0.01	0.07	0.92	-0.14	0.12	-0.01
Mother Education (LHS)	-0.01	0.05	0.90	-0.11	0.09	-0.01
Mother Education (HS)	0.02	0.05	0.64	-0.08	0.13	0.03
Mother Education (MHS)	0.02	0.07	0.74	-0.11	0.15	0.02
Books (10 or less)	-0.11	0.04	0.01	-0.20	-0.03	-0.12
Books (11-25)	-0.17	0.05	0.00	-0.26	-0.08	-0.15
Books (26-100)	-0.04	0.04	0.29	-0.12	0.04	-0.04
Prison education (LHS)	-0.05	0.05	0.30	-0.15	0.05	-0.03
Prison education (HS)	-0.05	0.04	0.15	-0.12	0.02	-0.05
Prison education (MHS)	0.15	0.04	0.00	0.07	0.22	0.11
Prison job	0.03	0.03	0.36	-0.03	0.09	0.03
Job readiness class	-0.01	0.03	0.76	-0.08	0.06	-0.01
Life skill class	-0.02	0.04	0.66	-0.09	0.06	-0.02
Job training class	-0.04	0.04	0.40	-0.12	0.05	-0.03
Library Use (Weekly)	0.07	0.05	0.16	-0.03	0.16	0.07
Library Use (Monthly)	0.11	0.05	0.02	0.02	0.19	0.09
Library Use (Once or twice a year)	0.08	0.06	0.18	-0.04	0.20	0.05
Library Use (Never)	0.07	0.05	0.19	-0.04	0.18	0.07
Prison release (< 6 months)	-0.24	0.07	0.00	-0.37	-0.11	-0.20
Prison release (6-12 months)	-0.19	0.07	0.01	-0.32	-0.05	-0.15
Prison release (1-2 years)	-0.16	0.07	0.02	-0.29	-0.03	-0.13
Prison release (2-5 years)	-0.16	0.06	0.01	-0.27	-0.04	-0.14
Prison release (> 5 years)	-0.17	0.07	0.01	-0.30	-0.05	-0.15
Prison numeracy engagement	0.02	0.01	0.01	0.00	0.03	0.07
Prison literacy engagement (Reading)	0.02	0.01	0.10	0.00	0.04	0.06
Prison literacy engagement (Writing)	0.01	0.01	0.35	-0.01	0.03	0.03
Literacy Intercept	2.35	0.13	0.00	2.09	2.61	5.10
Literacy Residual Variance	0.15	0.01	0.00	0.13	0.18	0.72
Literacy R-Square	0.28	0.03	0.00	—	—	—

Note. HS = high school. LHS = less than high school. MHS = more than high school. *b = Standardized Coefficients. LU: Lower Bound of the 95% confidence interval. UB: Upper Bound of the 95% confidence interval.

Table 7. Numeracy Model 2 - Main Effects of Background & Prison Factors

Numeracy Predictors	b	S.E.	*p*	95% CI LU	95% CI UB	*b
Youth	0.13	0.03	0.00	0.08	0.19	0.13
Female	-0.11	0.04	0.00	-0.18	-0.04	-0.05
White	0.14	0.09	0.10	-0.03	0.30	0.12
Black	-0.18	0.09	0.04	-0.34	-0.01	-0.16
Hispanic	0.05	0.09	0.58	-0.13	0.22	0.04
Native Speaker	0.24	0.06	0.00	0.12	0.37	0.16
Health Status	0.04	0.01	0.01	0.01	0.06	0.08
Education (LHS)	-0.37	0.05	0.00	-0.47	-0.27	-0.31
Father Education (LHS)	-0.07	0.05	0.23	-0.17	0.04	-0.05
Father Education (HS)	-0.03	0.05	0.58	-0.12	0.07	-0.03
Father Education (MHS)	0.01	0.07	0.88	-0.12	0.14	0.01
Mother Education (LHS)	0.06	0.07	0.36	-0.07	0.19	0.05
Mother Education (HS)	0.08	0.07	0.25	-0.06	0.22	0.08
Mother Education (MHS)	0.06	0.08	0.42	-0.09	0.22	0.05
Books (10 or less)	-0.07	0.05	0.12	-0.17	0.02	-0.07
Books (11-25)	-0.13	0.05	0.01	-0.24	-0.03	-0.10
Books (26-100)	-0.01	0.05	0.90	-0.11	0.10	-0.01
Prison education (LHS)	-0.02	0.05	0.74	-0.11	0.08	-0.01
Prison education (HS)	-0.07	0.04	0.06	-0.15	0.00	-0.06
Prison education (MHS)	0.18	0.05	0.00	0.09	0.27	0.11
Prison job	0.00	0.04	0.93	-0.08	0.07	0.00
Job readiness class	-0.02	0.04	0.57	-0.10	0.06	-0.02
Life skill class	0.02	0.04	0.72	-0.06	0.09	0.01
Job training class	0.00	0.04	0.93	-0.07	0.08	0.00
Library Use (Weekly)	0.07	0.06	0.22	-0.04	0.19	0.07
Library Use (Monthly)	0.15	0.06	0.02	0.03	0.27	0.11
Library Use (Once or twice a year)	0.16	0.07	0.03	0.01	0.30	0.09
Library Use (Never)	0.07	0.07	0.28	-0.06	0.20	0.06
Prison release (< 6 months)	-0.14	0.07	0.05	-0.28	0.00	-0.10
Prison release (6-12 months)	-0.07	0.07	0.27	-0.21	0.06	-0.05
Prison release (1-2 years)	-0.12	0.07	0.07	-0.25	0.01	-0.09
Prison release (2-5 years)	-0.09	0.06	0.13	-0.21	0.03	-0.07
Prison release (> 5 years)	-0.12	0.07	0.08	-0.25	0.02	-0.09
Prison numeracy engagement	0.02	0.01	0.01	0.01	0.04	0.07
Prison literacy engagement (Reading)	0.00	0.01	0.86	-0.02	0.02	0.01
Prison literacy engagement (Writing)	0.01	0.01	0.46	-0.01	0.03	0.02
Numeracy Intercept	1.88	0.15	0.00	1.59	2.18	3.52
Numeracy Residual Variance	0.19	0.01	0.00	0.17	0.22	0.67
Numeracy R-Square	0.33	0.03	0.00	—	—	—
Literacy with Numeracy						
Residual Covariance	0.13	0.01	0.00	0.11	0.15	—
Correlation	0.75	0.02	0.00	0.72	0.78	—

Note. HS = high school. LHS = less than high school. MHS = more than high school. *b = Standardized Coefficients. LU: Lower Bound of the 95% confidence interval. UB: Upper Bound of the 95% confidence interval.

Table 8. Literacy Model 3A - Main Effects of Background & Prison Factors

Literacy Predictors	b	S.E.	*p*	95% CI LU	95% CI UB	*b
Youth	0.14	0.12	0.24	-0.09	0.37	0.15
Female	-0.03	0.11	0.80	-0.25	0.19	-0.02
White	-0.12	0.22	0.59	-0.55	0.31	-0.12
Black	-0.31	0.22	0.17	-0.74	0.13	-0.32
Hispanic	-0.28	0.24	0.24	-0.74	0.19	-0.25
Native Speaker	0.19	0.07	0.00	0.06	0.32	0.15
Health Status	0.01	0.05	0.78	-0.08	0.10	0.03
Education (LHS)	-0.26	0.04	0.00	-0.35	-0.18	-0.26
Father Education (LHS)	-0.05	0.05	0.27	-0.14	0.04	-0.05
Father Education (HS)	-0.01	0.04	0.75	-0.09	0.06	-0.01
Father Education (MHS)	0.00	0.07	0.99	-0.14	0.13	0.00
Mother Education (LHS)	0.01	0.05	0.86	-0.08	0.10	0.01
Mother Education (HS)	0.04	0.05	0.40	-0.06	0.14	0.05
Mother Education (MHS)	0.03	0.06	0.62	-0.09	0.16	0.03
Books (10 or less)	-0.11	0.04	0.01	-0.20	-0.03	-0.12
Books (11-25)	-0.17	0.05	0.00	-0.26	-0.08	-0.15
Books (26-100)	-0.06	0.04	0.16	-0.13	0.02	-0.05
Prison education (LHS)	-0.05	0.05	0.30	-0.15	0.05	-0.03
Prison education (HS)	-0.05	0.04	0.15	-0.12	0.02	-0.05
Prison education (MHS)	0.16	0.04	0.00	0.08	0.23	0.12
Prison job	0.07	0.10	0.51	-0.13	0.27	0.07
Job readiness class	-0.02	0.15	0.91	-0.32	0.28	-0.02
Life skill class	0.06	0.12	0.62	-0.17	0.29	0.06
Job training class	0.12	0.14	0.40	-0.15	0.38	0.11
Library Use (Weekly)	0.07	0.05	0.19	-0.03	0.17	0.07
Library Use (Monthly)	0.10	0.05	0.04	0.01	0.20	0.08
Library Use (Once or twice a year)	0.07	0.06	0.24	-0.05	0.18	0.05
Library Use (Never)	0.06	0.06	0.26	-0.05	0.18	0.06
Prison release (< 6 months)	-0.25	0.07	0.00	-0.38	-0.12	-0.21
Prison release (6-12 months)	-0.20	0.07	0.00	-0.34	-0.07	-0.16
Prison release (1-2 years)	-0.17	0.07	0.01	-0.30	-0.04	-0.14
Prison release (2-5 years)	-0.17	0.06	0.01	-0.29	-0.05	-0.15
Prison release (> 5 years)	-0.19	0.07	0.00	-0.32	-0.06	-0.17
Prison numeracy engagement	-0.05	0.04	0.15	-0.13	0.02	-0.20
Prison literacy engagement (Reading)	0.04	0.04	0.32	-0.04	0.13	0.14
Prison literacy engagement (Writing)	-0.03	0.04	0.41	-0.10	0.04	-0.11

Note. HS = high school. LHS = less than high school. MHS = more than high school. *b = Standardized Coefficients. LU: Lower Bound of the 95% confidence interval. UB: Upper Bound of the 95% confidence interval.

Table 9. Literacy Model 3B - Interaction Effects of Background & Prison Factors

Literacy Predictors	b	S.E.	*p*	95% CI LU	95% CI UB	*b
Female X Health	0.00	0.03	0.92	-0.05	0.06	0.01
Youth X Health	-0.01	0.03	0.74	-0.06	0.04	-0.04
White X Health	0.02	0.05	0.67	-0.07	0.11	0.07
Black X Health	0.00	0.04	0.98	-0.09	0.09	-0.01
Hispanic X Health	0.04	0.05	0.40	-0.06	0.14	0.14
Female X Job Readiness	0.01	0.07	0.85	-0.12	0.14	0.00
Youth X Job Readiness	0.02	0.06	0.70	-0.09	0.14	0.02
White X Job Readiness	0.00	0.16	0.98	-0.32	0.33	0.00
Black X Job Readiness	0.03	0.15	0.87	-0.27	0.32	0.02
Hispanic X Job Readiness	-0.10	0.17	0.55	-0.43	0.23	-0.04
Female X Life Skills	0.05	0.08	0.58	-0.11	0.20	0.02
Youth X Life Skills	0.12	0.07	0.07	-0.01	0.25	0.09
White X Life Skills	-0.14	0.14	0.30	-0.41	0.13	-0.10
Black X Life Skills	-0.16	0.13	0.22	-0.42	0.10	-0.12
Hispanic X Life Skills	-0.10	0.14	0.47	-0.36	0.17	-0.05
Female X Job Training	-0.01	0.06	0.85	-0.13	0.11	0.00
Youth X Job Training	0.03	0.06	0.61	-0.09	0.15	0.02
White X Job Training	-0.15	0.15	0.31	-0.44	0.14	-0.09
Black X Job Training	-0.17	0.14	0.21	-0.44	0.10	-0.10
Hispanic X Job Training	-0.25	0.14	0.07	-0.51	0.02	-0.12
Female X Prison Job	-0.03	0.07	0.67	-0.16	0.10	-0.01
Youth X Prison Job	-0.01	0.06	0.89	-0.13	0.12	-0.01
White X Prison Job	-0.02	0.12	0.84	-0.26	0.21	-0.02
Black X Prison Job	-0.04	0.10	0.67	-0.25	0.16	-0.04
Hispanic X Prison Job	-0.01	0.12	0.95	-0.24	0.22	-0.01
Female X Literacy Engagement (Writing)	-0.01	0.02	0.64	-0.04	0.02	-0.01
Female X Literacy Engagement (Reading)	-0.01	0.02	0.83	-0.05	0.04	-0.01
Female X Numeracy Engagement	0.00	0.02	0.99	-0.04	0.04	0.00
Youth X Literacy Engagement (Writing)	0.00	0.02	0.99	-0.03	0.03	0.00
Youth X Literacy Engagement (Reading)	-0.01	0.03	0.69	-0.06	0.04	-0.04
Youth X Numeracy Engagement	0.00	0.02	0.95	-0.03	0.03	0.00
White X Literacy Engagement (Writing)	0.05	0.04	0.20	-0.03	0.13	0.17
White X Literacy Engagement (Reading)	-0.03	0.04	0.45	-0.12	0.05	-0.12
White X Numeracy Engagement	0.07	0.04	0.07	-0.01	0.14	0.23
Black X Literacy Engagement (Writing)	0.04	0.04	0.26	-0.03	0.12	0.15
Black X Literacy Engagement (Reading)	-0.02	0.05	0.74	-0.11	0.08	-0.06
Black X Numeracy Engagement	0.09	0.04	0.02	0.02	0.16	0.29
Hispanic X Literacy Engagement (Writing)	0.03	0.04	0.48	-0.05	0.11	0.08
Hispanic X Literacy Engagement (Reading)	-0.01	0.04	0.89	-0.09	0.08	-0.02
Hispanic X Numeracy Engagement	0.07	0.04	0.09	-0.01	0.16	0.20
Literacy Intercept	2.56	0.25	0.00	2.06	3.05	5.55
Literacy Residual Variance	0.15	0.01	0.00	0.13	0.17	0.70
Literacy R-Square	0.30	0.03	0.00	—	—	—

Note. *b = Standardized Coefficients. LU: Lower Bound of the 95% confidence interval. UB: Upper Bound of the 95% confidence interval.

Table 10. Numeracy Model 3A - Main Effects of Background & Prison Factors

Numeracy Predictors	b	S.E.	*p*	95% CI LB	95% CI UB	*b
Youth	0.13	0.13	0.31	-0.12	UB	0.12
Female	0.08	0.11	0.44	-0.13	0.30	0.04
White	-0.07	0.25	0.80	-0.56	0.43	-0.06
Black	-0.33	0.25	0.19	-0.83	0.17	-0.30
Hispanic	-0.12	0.28	0.68	-0.67	0.44	-0.09
Native Speaker	0.26	0.07	0.00	0.13	0.38	0.17
Health Status	0.07	0.05	0.21	-0.04	0.17	0.14
Education (LHS)	-0.37	0.05	0.00	-0.46	-0.28	-0.32
Father Education (LHS)	-0.07	0.05	0.16	-0.17	0.03	-0.06
Father Education (HS)	-0.03	0.05	0.49	-0.12	0.06	-0.03
Father Education (MHS)	0.01	0.07	0.89	-0.13	0.15	0.01
Mother Education (LHS)	0.08	0.07	0.21	-0.05	0.21	0.07
Mother Education (HS)	0.10	0.07	0.15	-0.04	0.24	0.09
Mother Education (MHS)	0.09	0.07	0.23	-0.06	0.24	0.07
Books (10 or less)	-0.07	0.05	0.15	-0.17	0.02	-0.06
Books (11-25)	-0.14	0.05	0.01	-0.24	-0.03	-0.10
Books (26-100)	-0.02	0.05	0.74	-0.12	0.08	-0.01
Prison education (LHS)	-0.02	0.05	0.72	-0.11	0.08	-0.01
Prison education (HS)	-0.07	0.04	0.07	-0.15	0.01	-0.06
Prison education (MHS)	0.19	0.05	0.00	0.10	0.28	0.12
Prison job	0.02	0.12	0.86	-0.22	0.26	0.02
Job readiness class	-0.16	0.14	0.25	-0.43	0.11	-0.13
Life skill class	0.11	0.13	0.41	-0.15	0.36	0.09
Job training class	0.28	0.13	0.04	0.02	0.54	0.22
Library Use (Weekly)	0.08	0.06	0.17	-0.04	0.20	0.07
Library Use (Monthly)	0.15	0.06	0.02	0.02	0.27	0.11
Library Use (Once or twice a year)	0.16	0.07	0.03	0.02	0.31	0.09
Library Use (Never)	0.08	0.06	0.22	-0.05	0.21	0.07
Prison release (< 6 months)	-0.15	0.07	0.03	-0.29	-0.01	-0.11
Prison release (6-12 months)	-0.09	0.07	0.21	-0.23	0.05	-0.06
Prison release (1-2 years)	-0.14	0.07	0.05	-0.27	0.00	-0.10
Prison release (2-5 years)	-0.10	0.06	0.10	-0.22	0.02	-0.08
Prison release (> 5 years)	-0.13	0.07	0.05	-0.26	0.00	-0.10
Prison numeracy engagement	-0.06	0.04	0.17	-0.13	0.02	-0.18
Prison literacy engagement (Reading)	0.00	0.04	0.98	-0.08	0.08	0.00
Prison literacy engagement (Writing)	-0.03	0.05	0.56	-0.12	0.07	-0.09

Note. HS = high school. LHS = less than high school. MHS = more than high school. *b = Standardized Coefficients. LU: Lower Bound of the 95% confidence interval. UB: Upper Bound of the 95% confidence interval.

Table 11. Numeracy Model 3B - Interaction Effects of Background & Prison Factors

Numeracy Predictors	b	S.E.	*p*	95% CI LB	95% CI UB	*b
Female X Health	-0.02	0.02	0.42	-0.07	0.03	-0.03
Youth X Health	-0.01	0.03	0.86	-0.06	0.05	-0.02
White X Health	-0.02	0.06	0.69	-0.14	0.09	-0.08
Black X Health	-0.03	0.05	0.55	-0.14	0.07	-0.11
Hispanic X Health	-0.02	0.05	0.66	-0.13	0.08	-0.07
Female X Job Readiness	-0.05	0.08	0.54	-0.20	0.11	-0.01
Youth X Job Readiness	0.08	0.08	0.30	-0.07	0.23	0.05
White X Job Readiness	0.15	0.15	0.29	-0.13	0.44	0.08
Black X Job Readiness	0.09	0.14	0.54	-0.19	0.36	0.05
Hispanic X Job Readiness	0.04	0.17	0.80	-0.29	0.37	0.02
Female X Life Skills	0.01	0.08	0.87	-0.15	0.18	0.00
Youth X Life Skills	-0.03	0.07	0.72	-0.17	0.11	-0.02
White X Life Skills	-0.13	0.15	0.36	-0.42	0.15	-0.08
Black X Life Skills	-0.09	0.14	0.53	-0.35	0.18	-0.05
Hispanic X Life Skills	0.02	0.14	0.89	-0.25	0.29	0.01
Female X Job Training	0.04	0.08	0.66	-0.12	0.19	0.01
Youth X Job Training	0.00	0.06	0.99	-0.12	0.13	0.00
White X Job Training	-0.28	0.14	0.04	-0.55	-0.02	-0.15
Black X Job Training	-0.28	0.13	0.03	-0.54	-0.02	-0.14
Hispanic X Job Training	-0.34	0.13	0.01	-0.59	-0.10	-0.14
Female X Prison Job	-0.05	0.07	0.49	-0.19	0.09	-0.02
Youth X Prison Job	0.05	0.07	0.48	-0.09	0.18	0.04
White X Prison Job	-0.05	0.12	0.69	-0.28	0.19	-0.04
Black X Prison Job	-0.08	0.13	0.56	-0.33	0.18	-0.06
Hispanic X Prison Job	0.00	0.13	0.98	-0.26	0.25	0.00
Female X Literacy Engagement (Writing)	-0.02	0.02	0.28	-0.05	0.02	-0.03
Female X Literacy Engagement (Reading)	0.01	0.03	0.79	-0.04	0.06	0.01
Female X Numeracy Engagement	-0.02	0.02	0.30	-0.07	0.02	-0.04
Youth X Literacy Engagement (Writing)	0.01	0.02	0.59	-0.03	0.06	0.04
Youth X Literacy Engagement (Reading)	-0.02	0.03	0.51	-0.07	0.03	-0.06
Youth X Numeracy Engagement	0.00	0.02	0.98	-0.04	0.04	0.00
White X Literacy Engagement (Writing)	0.06	0.05	0.25	-0.04	0.15	0.17
White X Literacy Engagement (Reading)	0.00	0.05	0.93	-0.10	0.09	-0.01
White X Numeracy Engagement	0.09	0.04	0.04	0.01	0.17	0.24
Black X Literacy Engagement (Writing)	0.02	0.05	0.67	-0.08	0.12	0.06
Black X Literacy Engagement (Reading)	0.03	0.05	0.56	-0.07	0.12	0.09
Black X Numeracy Engagement	0.08	0.04	0.05	0.00	0.16	0.24
Hispanic X Literacy Engagement (Writing)	0.01	0.06	0.82	-0.10	0.12	0.03
Hispanic X Literacy Engagement (Reading)	0.02	0.05	0.76	-0.08	0.11	0.04
Hispanic X Numeracy Engagement	0.08	0.05	0.09	-0.01	0.17	0.19
Numeracy Intercept	2.01	0.26	0.00	1.51	2.51	3.76
Numeracy Residual Variance	0.19	0.01	0.00	0.16	0.21	0.65
Numeracy R-Square	0.35	0.03	0.00	—	—	—
Literacy with Numeracy						
Residual Covariance	0.13	0.01	0.00	0.11	0.15	—
Correlation	0.75	0.02	0.00	0.72	0.79	—

Note. *b = Standardized Coefficients. LU: Lower Bound of the 95% confidence interval. UB: Upper Bound of the 95% confidence interval.

APPENDICES

Appendix A

Appendix A.1

Table 12. Model Variables and Descriptions

Variable	Variable Name in PIAAC	Description
Gender	GENDER_R	"Person resolved gender from background questionnaire"
Age	AGE1634	Age of incarcerated adults (16-34/35-74)
Race	RACETHN_4CA T	Race/Ethnicity
Native Speaker	NATIVESPEAKER	"Respondent is a native speaker"
Education Prior to Prison	B_Q01AUS_C	Education - highest qualification - level (3 categories)
Father's Education	J_Q07BUS	"What was the highest level of education your father or male guardian ever completed?"
Mother's Education	J_Q06BUS	"What was the highest level of education your mother or female guardian ever completed?"
Reading Experience (Number of Books at Home)	J_Q08	"About how many books are/were there in your home when you were 16 years old? Do not include magazines, newspapers or schoolbooks. To give an estimation, one foot of shelving is about 10 books."
Prison Education (Completed)	P_Q120	"During your current period of incarceration, what is the highest level of education you completed?"
Job Readiness	P_Q190A	"During your current incarceration, have you attended employment readiness or re-entry classes (including how to find a job or interviewing skills)"
Life Skills	P_Q190C	"During your current incarceration, have you attended classes in life skills such as personal finance, problem solving, decision making?"
Job Training	P_Q220	"During your current period of incarceration, have you participated in a job skills or job training program, for example, a computer skills program that teaches Microsoft Word? Please exclude prison jobs."
Prison Job	P_Q390	"Do you currently have any prison job?"
Health Status	I_Q08	"In general, would you say your health is excellent, very good, good, fair, or poor?"
Time Remaining in Prison	P_Q180	"When do you expect to be released from prison?"
Library Use	P_Q370	"How often do you use the services of a library for any reason?"
Writing Engagement	WRITHOMEUSP_WLE_CA	"Index of use of writing skills in everyday life (in prison)"
Reading Engagement	READHOMEUSP_WLE_CA	"Index of use of reading skills in everyday life (in prison) (prose and document texts)"

Numeracy Engagement	NUMHOMEUSP_WLE_CA	"Index of use of numeracy skills in everyday life (in prison) (basic and advanced)"
Literacy	PVLIT1-PVLIT10	Literacy assessment plausible values
Numeracy	PVNUM1-PVNUM10	Numeracy assessment plausible values
Sample Weight	SPFWT0	Final full sample weight
Replicate Weight	SPFWT1-SPFWT80	Final replicate weights

Note. PIAAC = Program for the International Assessment of Adult Competencies. PIAAC variable names are provided for reference to the original survey.

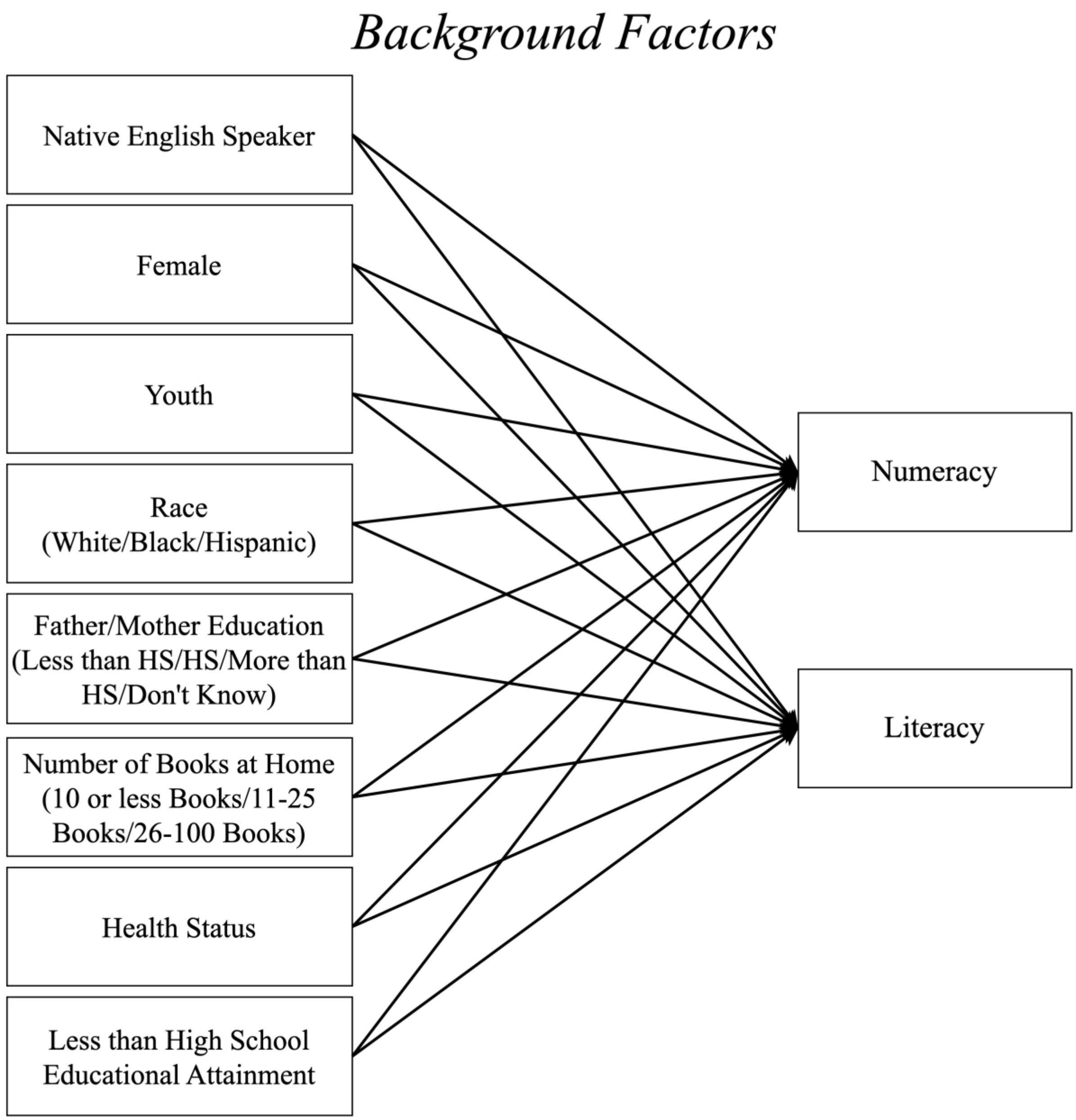


Figure 1. Diagram of Model Background Factors
Note. HS = High School

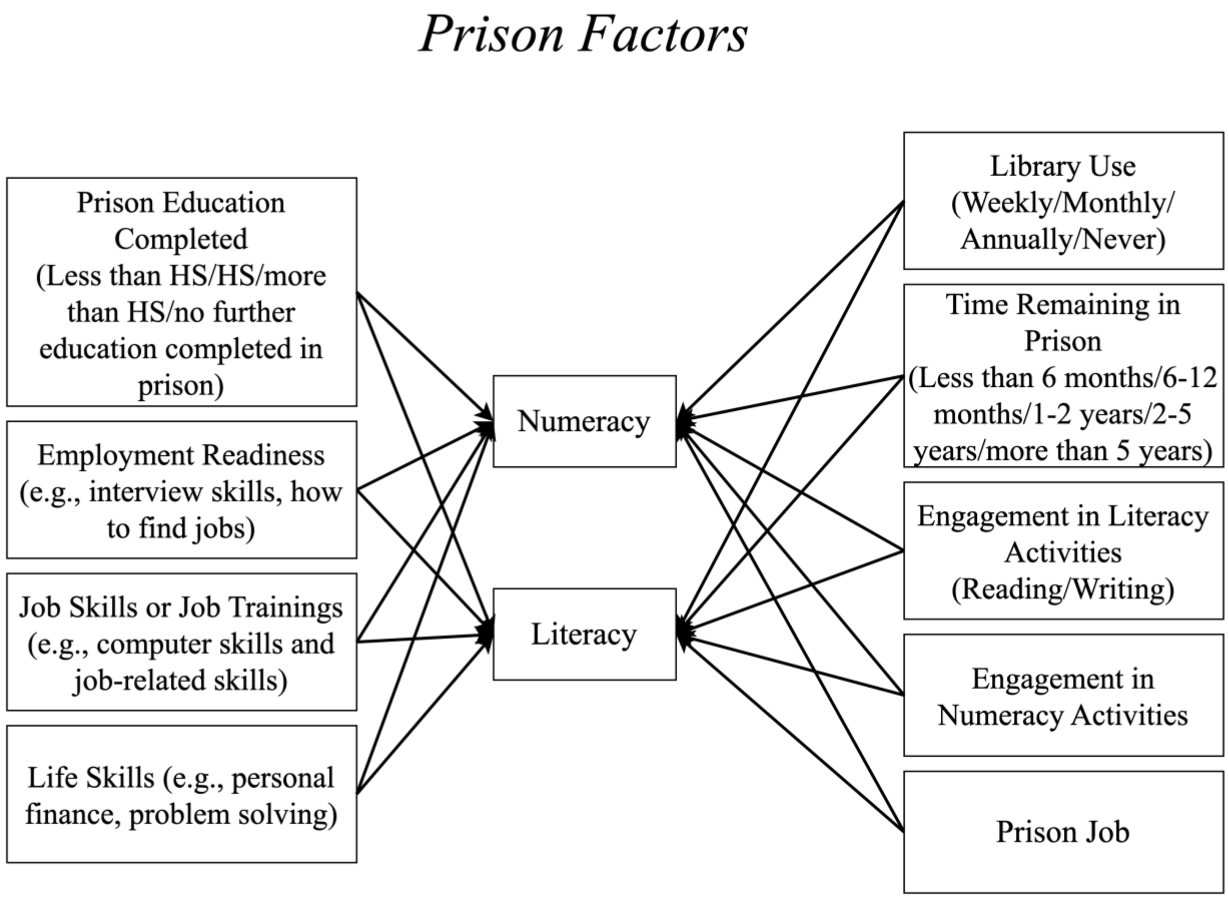


Figure 2. Diagram of Model Prison Factors
Note. HS = High School

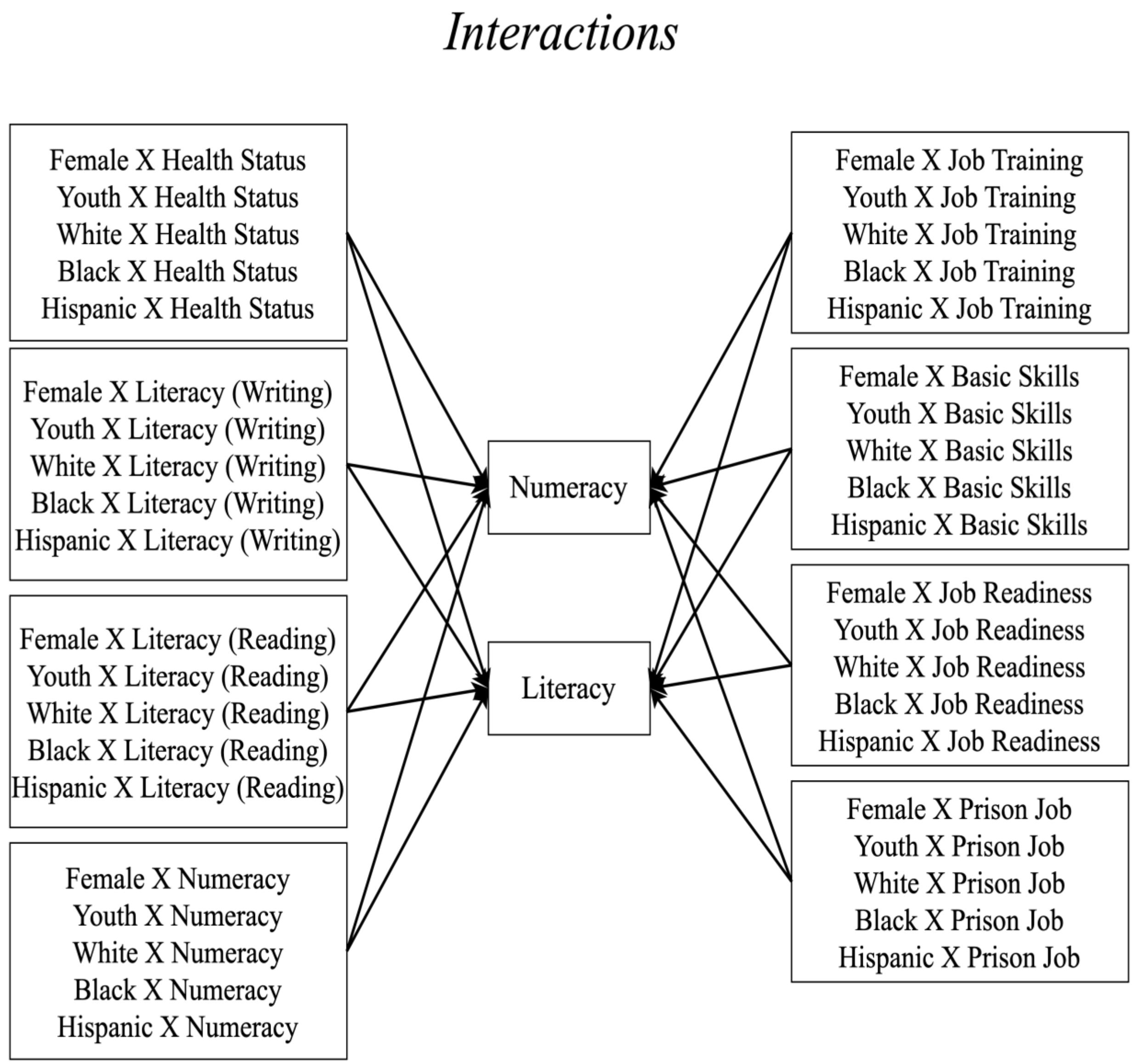


Figure 3. Diagram of Model Interactions

Appendix B

Appendix B.1

Table 13. PIAAC Literacy and Numeracy Engagement Activities at Work and Everyday

Skills		**Engagement Activities/ Practices**
Literacy		
Reading	Work and Everyday Life	Read directions or instructions Read letters, memos, or emails Read newspapers, magazines, or journals Read professional journals or publications Read books Read manuals or reference materials Read financial statements Read diagrams, maps, or schematics.
Writing	Work and Everyday Life	Write letters, memos, or emails Write articles (for newspapers or magazines) Write reports; Fill in forms.
Numeracy	Work and Everyday Life	Calculating costs or budgets Use or calculate fractions or percentages Use a calculator Prepare charts, graphs, or tables Use simple algebra or formulas Use advanced math or statistics

Appendix B.2

Table 14. PIAAC Literacy Proficiency Levels

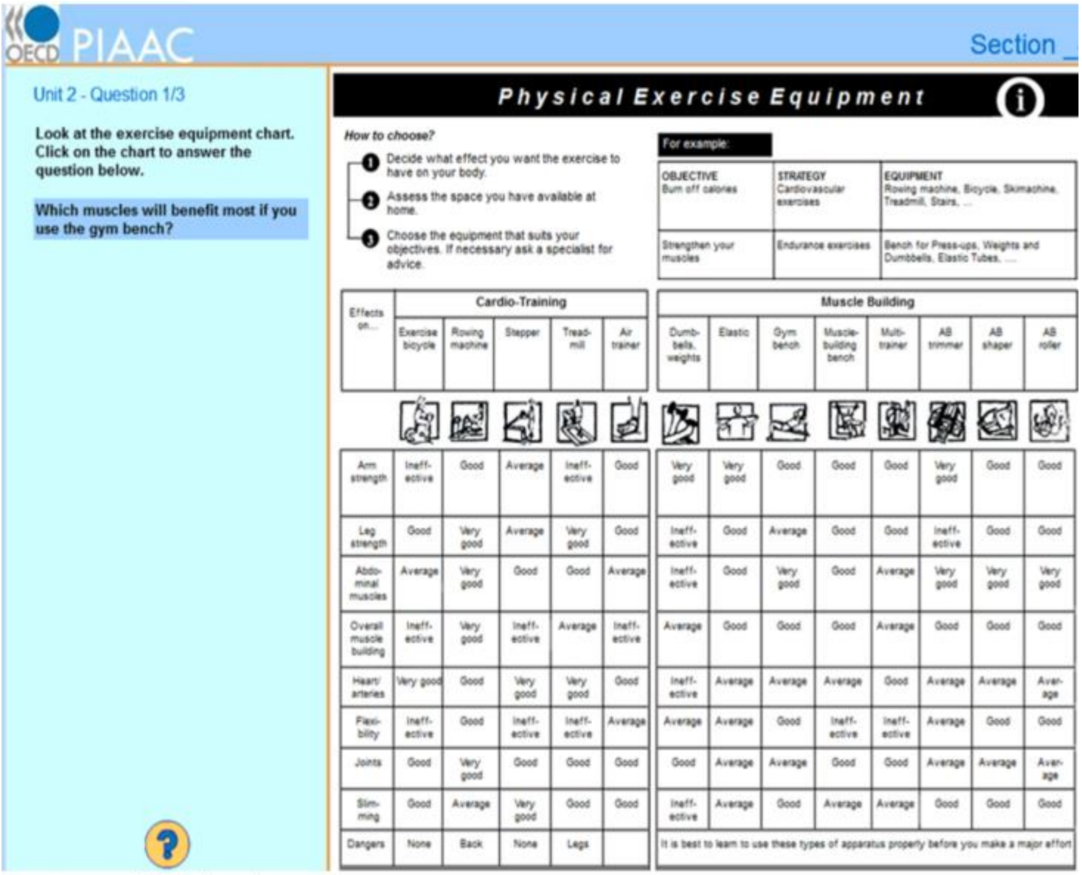
Proficiency Level	Skill/Task
Below Level 1 (0-175)	Finding simple pieces of information in text
Level 1 (176-225)	Reading short digital, print, or mixed texts and locating information
Level 2 (226-275)	Making connections between text and information, minimal paraphrasing and inferencing
Level 3 (276-325)	Identifying, interpreting, and evaluating texts that require different inferencing skills
Level 4 (326-375)	Interpreting information from complex texts and applying complex inferencing strategies
Level 5 (376-500)	Locating and interpreting information from complex various text types and structures, constructing main ideas, and evaluating evidence-based arguments

Table 15. PIAAC Numeracy Proficiency Levels

Proficiency Level	Skill/Task
Below Level 1 (0-175)	Perform basic counting and arithmetic tasks with whole numbers
Level 1 (176-225)	Perform one-step arithmetic operations and understand simple percentage concepts (e.g., 25%)
Level 2 (226-275)	Perform simple calculations, measurements, and estimations, and interpret basic tables and graphs
Level 3 (276-325)	Understand mathematical patterns, proportions, and simple statistics
Level 4 (326-375)	Perform complex reasoning and statistics and provide well-reasoned answers and explanations
Level 5 (376-500)	Understand complex math and statistical ideas, understand math ideas in complex texts, draw inferences and evaluate different solutions

Appendix C

Appendix C.1



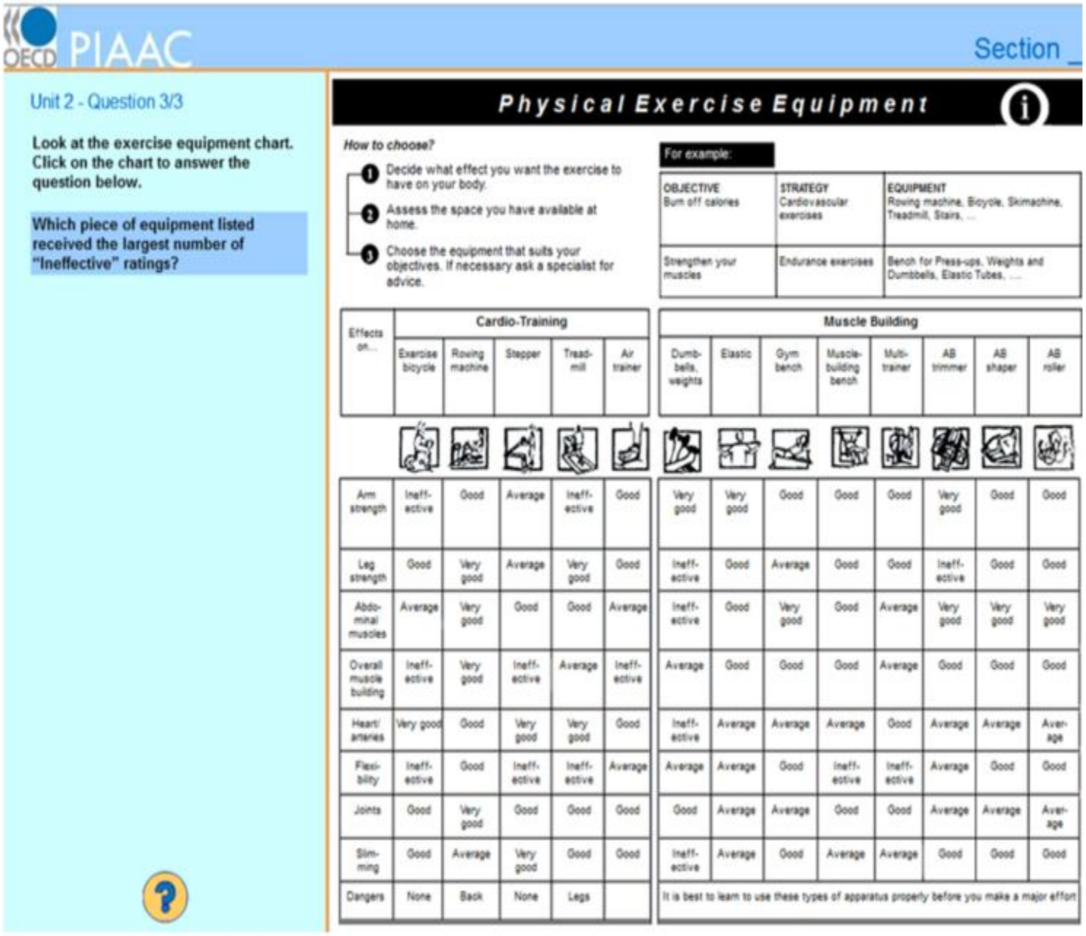
Effects on...	Cardio-Training					Muscle Building							
	Exercise bicycle	Rowing machine	Stepper	Tread-mill	Air trainer	Dumb-bells, weights	Elastic	Gym bench	Muscle-building bench	Multi-trainer	AB trimmer	AB shaper	AB roller
Arm strength	Ineff-ective	Good	Average	Ineff-ective	Good	Very good	Very good	Good	Good	Good	Very good	Good	Good
Leg strength	Good	Very good	Average	Very good	Good	Ineff-ective	Good	Average	Good	Good	Ineff-ective	Good	Good
Abdo-minal muscles	Average	Very good	Good	Good	Average	Ineff-ective	Good	Very good	Good	Average	Very good	Very good	Very good
Overall muscle building	Ineff-ective	Very good	Ineff-ective	Average	Ineff-ective	Average	Good	Good	Good	Average	Good	Good	Good
Heart/ arteries	Very good	Good	Very good	Very good	Good	Ineff-ective	Average	Average	Average	Good	Average	Average	Aver-age
Flexi-bility	Ineff-ective	Good	Ineff-ective	Ineff-ective	Average	Average	Average	Good	Ineff-ective	Ineff-ective	Average	Good	Good
Joints	Good	Very good	Good	Good	Good	Good	Average	Average	Good	Good	Average	Average	Aver-age
Slim-ming	Good	Average	Very good	Good	Good	Ineff-ective	Average	Good	Average	Average	Good	Good	Good
Dangers	None	Back	None	Legs		It is best to learn to use these types of apparatus properly before you make a major effort							

Correct response: Abdominal muscles.

Figure 4. Literacy Sample Item 1.

This is a level 2 difficulty literacy item. This item assesses the participant's ability to access and identify information provided in the chart to answer the question.

Appendix C.2



OECD PIAAC

Section _

Unit 2 - Question 3/3

Look at the exercise equipment chart. Click on the chart to answer the question below.

Which piece of equipment listed received the largest number of "Ineffective" ratings?

Physical Exercise Equipment

How to choose?

1. Decide what effect you want the exercise to have on your body.
2. Assess the space you have available at home.
3. Choose the equipment that suits your objectives. If necessary ask a specialist for advice.

For example:

OBJECTIVE	STRATEGY	EQUIPMENT
Burn off calories	Cardiovascular exercises	Rowing machine, Bicycle, Skimachine, Treadmill, Stairs, ...
Strengthen your muscles	Endurance exercises	Bench for Press-ups, Weights and Dumbbells, Elastic Tubes, ...

Effects on...	Cardio-Training					Muscle Building							
	Exercise bicycle	Rowing machine	Stepper	Tread-mill	Air trainer	Dumb-bells, weights	Elastic	Gym bench	Muscle-building bench	Multi-trainer	AB trimmer	AB shaper	AB roller
Arm strength	Ineff-ective	Good	Average	Ineff-ective	Good	Very good	Very good	Good	Good	Good	Very good	Good	Good
Leg strength	Good	Very good	Average	Very good	Good	Ineff-ective	Good	Average	Good	Good	Ineff-ective	Good	Good
Abdo-minal muscles	Average	Very good	Good	Good	Average	Ineff-ective	Good	Very good	Good	Average	Very good	Very good	Very good
Overall muscle building	Ineff-ective	Very good	Ineff-ective	Average	Ineff-ective	Average	Good	Good	Good	Average	Good	Good	Good
Heart/ arteries	Very good	Good	Very good	Very good	Good	Ineff-ective	Average	Average	Average	Good	Average	Average	Aver-age
Flexi-bility	Ineff-ective	Good	Ineff-ective	Ineff-ective	Average	Average	Average	Good	Ineff-ective	Ineff-ective	Average	Good	Good
Joints	Good	Very good	Good	Good	Good	Good	Average	Average	Good	Good	Average	Average	Aver-age
Slim-ming	Good	Average	Very good	Good	Good	Ineff-ective	Average	Good	Average	Average	Good	Good	Good
Dangers	None	Back	None	Legs		It is best to learn to use these types of apparatus properly before you make a major effort							

Correct response: Dumb bells/weights.

Figure 5. Literacy Sample Item 2.

This is a level 2 difficulty literacy item. This item assesses the participant's ability to integrate and interpret information provided in the chart to answer the question.

Appendix C.3

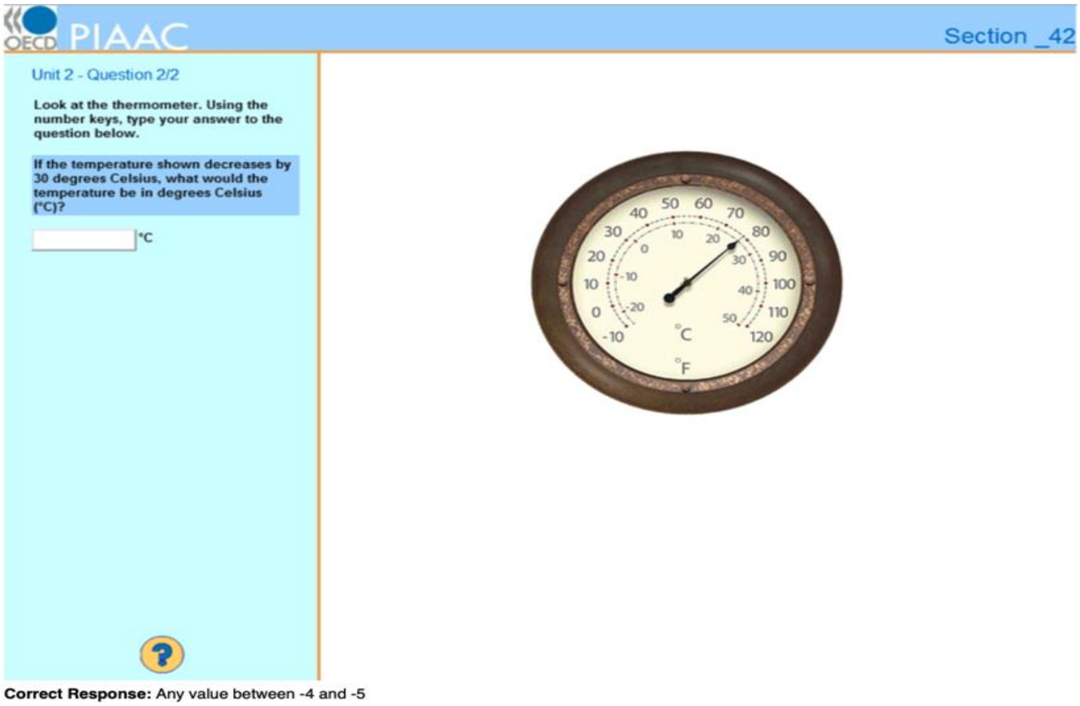


Figure 6. *Numeracy Sample Item.*

This numeracy item is a level 1 difficulty item, and it assesses the participants on their dimension and shape knowledge. Based on the graphic provided, the participant is required to use basic numeracy skills to answer the question.