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Numeracy and Adults' Learning Readiness and Commitment: Results from a Large National Random Sample of Participants

Jennifer Hollinger
Mount Union University

Karen Larwin
Youngstown State University

The rapid changes in our society have amplified the need for adult learning opportunities. However, adults often make decisions not to persist in formal learning experiences in a smooth, linear fashion. The decision to pause or terminate formal learning is a complex behavioral decision that includes knowledge, the cognitive process, personal belief, and environmental context. Because the construct of numeracy also necessitates the use of content, cognitive processes, dispositions, and context, this study examined the link between adults' numeracy abilities and learning readiness and commitment. This study analyzed the program for the International Assessment of Adult Competencies (PIAAC) Survey Adult Skills which was collected via a representative national random sample. The findings suggest numeracy abilities have a small, positive relationship to readiness to learn and learning persistence.

In our constantly changing world, where new knowledge and technologies emerge each day, the gap between what individuals know and what they need to know is ever-widening (Robinson & Aronica, 2015; Wagner, 2010). Cross (1992) contended that change in society has become so great "that no amount of education during youth can prepare adults to meet the demands that will be made on them" (p. 2). Therefore, in order to thrive, adults must learn. Adult learning can range from watching YouTube videos in order to gain new skills to studying for advanced degrees at a post-secondary institution. Regardless of the formality, adult learning occurs in pursuit of personal goals (Comings, Parrella, & Soricone, 1999; Courtney, 1992; Ginsberg & Wlodkowski, 2010; Rubenson, 1977; Schleicher, 2013; Tough, 1979).

Due to the complexities of adult life, adult formal learning does not always occur in a smooth, linear fashion. Temporary pauses in the formal learning process often occur, not because adults are uncommitted, but rather, because they must make choices about personal priorities and goals (Comings, 2007). Therefore, the definition of learning persistence for adult learners must be framed with these dynamics in mind. Comings et al. (1999) explained that adult persistence should be defined as "adults staying in programs for as long as they can, engaging in self-directed study when they must drop out of their programs, and returning to programs as soon as the demands of their lives allow" (p. 3). The method and the pace of adult formal learning are choices. Therefore, to understand an adult's commitment to partake and persist in formal learning experiences, the decision-making process to initiate formal learning, exit formal learning, and reengage in formal learning must be explored to identify mechanisms to assist adult learners in completion of their personal formal learning goals. Investment in formal education does not come without a cost, and that cost is often not offset with the reward of a formal qualification when adult learners fail to persist.

Bernanke (2007) declared that "deciding how much to invest in their education is one of the most important economic decisions people make during the course of their lives" (Bernanke, 2007, para. 4). Because educational decisions, like other economic decisions are not made in a vacuum, individuals respond differently based on personal experiences and beliefs, understanding of facts, and environmental framing of the situation (DellaVigna, 2009; von Winterfeldt, 2013). Thus, behavioral economists seek to understand the intricacies of this process to discover a conduit to better decision making.

Because decision making integrates cognitive processes, environmental context, and personal beliefs, researchers have explored a link between decision making and numeracy. Numeracy, or the "the ability to access, use, interpret, and communicate mathematical information and ideas, in order to engage in and manage the mathematical demands of a range of situations in adult life," may seem like an unlikely indicator of behavioral economic decision, but the opposite is true (PIAAC Numeracy Expert Group, 2009, p. 21). Numeracy, like decision-making, requires the use of knowledge and cognition combined with personal values and beliefs. Also, like decision-making, numeracy behaviors are entrenched in an individual's personal environment, allowing him to "effectively cope with or respond to a range of situations that are embedded in a life stream with real, personal meaning to them" (PIAAC Numeracy Expert Group, 2009, p. 15). Thus, there is a large intersection between the constructs of decision-making and numeracy.

Numeracy Defined

Numeracy can be thought of as the complement of literacy. The term originated in 1959 as part of the Crowther's report (Ministry of Education, 1959). Initially, the term carried the idea of not only quantitative, but also scientific reasoning (Ministry of

Education, 1959). However, more recent constructs of the term lean toward practical application of mathematical life skills. While there are many interpretations of what numeracy entails, the analysis of formal definitions and framework reveals four themes: content, cognitive processes, dispositions, and context.

Ginsburg's, Manly's, and Schmitt's (2006) study, which compared many numeracy frameworks, created four classifications of adult numeracy content:

- Number and Operation Sense;
- Patterns, Functions, and Algebra;
- Measurement and Shape; and
- Data, Statistics, and Probability.

While numeracy content can be agreeably categorized into four major areas, these boundaries are not clean breaks between the groupings and thus cannot be mastered in isolation to one another. Ginsburg et al. (2006) suggested, "Numeracy skills do not stop at 'being good with numbers.' Numeracy for the twenty-first century is a much richer construct" and therefore, a broad and deep understanding of numeracy is essential (p. 19). In fact, many numeracy assessment frameworks identify cognitive processes associated with numeracy alongside the content categories.

A cognitive process is a way that individuals acquire and make meaning of new knowledge (Garner, 2007). Condelli (2006) outlined a cognitive process framework for numeracy that consisted of three levels. This framework, developed during Maguire's and O'Donoghue's (2002) presentation at the International Conference for the Adult Learning of Mathematics, demonstrates that cognition skills in numeracy-based scenarios increase in complexity. The lowest level of complexity is a routine replication of basic arithmetic (Maguire & O'Donoghue, 2002). Evans, Waite, and Admasachew (2009) called this the limited proficiency model, which requires simple recall, no application, and a very low level of cognition. The complexity increases to application of knowledge to everyday life.

Numeracy is context-dependent. This delineates numeracy from mathematics. Mathematics is "pure and context-free," whereas, numeracy has a "distinctive personal element" that is embraced uniquely by each individual (Ginsburg et al., 2006, p. 1). Thus, numeracy, "unlike mathematics…, does not so much lead upward in an ascending pursuit of abstraction as it moves outward toward an ever richer engagement with life's diverse contexts and situations" (Orrill, 2001, p. xviii). The OECD (2013) suggested that numeracy "assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged, and reflective citizens" (p. 25). The complexity builds to a "complex, multifaceted, and sophisticated construct, incorporating the mathematics, communication, cultural, social, emotional, and personal aspects of each individual in context" (Condelli, 2006, p. 7; Maguire & O'Donoghue, 2002). At this level, individuals are "empowered as 'knowledge producers' as well as 'knowledge consumers'—that is, to be technologically, socially, personally, and/or democratically numerate" (Maclean & Wilson, 2009, p. 2737). Growing complexity of cognition is not necessarily a simple linear process disconnected from other life factors.

While cognition can be advanced at any age or life stage (Garner, 2007), in order to apply numeracy skills in these sophisticated ways, learners must possess the relevant schema to organize and process numerical information. If this does not exist, "it reinforces the idea that mathematics makes no sense and the belief that the student is not good at math and has no hope of mastering it" (Wallace, 2011, p. 6). Fitzsimons (2005) advocated, "The formal activity of learning mathematics at any stage of life is intimately bound up with the identity of the learner" (p.13). Thus, any disconnect between skill level and cognition level can be the cause of negative impact on a learner's identity.

Learner numeracy identity, particularly in adults, is complex and built over time, across many interactions with numerical concepts. These repeated interactions establish beliefs that begin to stabilize and define an individual's personal conception of their ability. These affective beliefs, or dispositions, cannot be divorced from the cognitive work of mathematics. Kilpatrick, Swafford, Findell, and National Research Council (U.S.), (2001) defined disposition of mathematics as the following:

> The tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics. If students are to develop conceptual understanding, procedural fluency, strategic competence, and adaptive reasoning abilities, they must believe that mathematics is understandable, not arbitrary; that, with diligent effort, it can be learned and used; and that they are capable of figuring it out (p. 131).

While a negative disposition towards mathematics does not necessarily correlate to low intellect and can exist in individuals who possess strong cognitive ability, negative dispositions can form a barrier to adult learning (Ginsburg & Asmussen, 1988). Ginsburg and Asmussen (1988) referred to this strong relationship between feelings, emotions, and personal meanings as "hot mathematics" (p. 89). Consequently, as individuals' negative dispositions are linked to numeracy, their perceived self-efficacy can decline.

Bandura (1977) described self-efficacy as "beliefs in one's capabilities to organize and execute the course of action required to produce given achievements" (p. 3). Adult self-efficacy, while forward-focused on future outcomes, is built largely on past experiences. Of all aspects of self-perception, self-efficacy is the strongest predictor of adult behavior (Bong & Skaalvik, 2003; Wlodkowski, 2008). To build self-efficacy in learners, one strategy often employed is to remove the level of sophistication and cognitive demand from the learning situation. However, Noss (1998) warned that by moving toward what is learnable (facts and recall), one moves away from what is valuable (application and creation). Accordingly, if complexity is divorced from numeracy for the sake of building self-efficacy, adults may gain a more positive disposition toward the subject but make lack the ability to apply skills within a rich social environment. Thus, the process of building self-efficacy related to numeracy must move adults to the highest cognitive levels so that they are able to employ their skills and dispositions to make life decisions that allow them to achieve personal goals.

Therefore, adult numeracy is a complex process which holds the potential for enduring impact across life's many circumstances. Researchers, primarily in the fields of medicine and finance, have revealed this intersection. Studies have shown that high numeracy predicts better judgment, superior risk analysis, and more measured decisions (Benjamin, Brown, & Shapiro, 2013; Jasper, Bhattacharya, Levin, Jones, & Bossard, 2013; Pachur & Galesic, 2013; Peters, 2012). Since behavioral economists have related numeracy to individuals' choices, numeracy may potentially be a strong predictor of adults' decisions to be committed to learning.

Research in remedial numeracy programs has revealed positive correlations between increased numeracy abilities and adult learning trajectory. Bynner and Parsons (2009) suggested, "Skills supply the basic protective resources on which successful achievement in adult life is likely to be based, and at the core of these resources lie literacy and numeracy without which progress is likely impeded" (p. 29). Furthermore, adults who lack literacy and numeracy skills have "increasing risk of marginalization and social exclusion" (Bynner & Parsons, 2009, p. 29). Similarly, Metcalf and Meadows (2009) suggested that adults in literacy and numeracy programs created "a stronger sense of themselves as people and as learners; perhaps this first tentative step into learning will be the catalyst that enables them to fight back against existing power and privilege" (p. 346). Maclachlan, Tett, and Hall (2009) provided evidence that this may be true as they discovered that adults involved in these programs were significantly more likely to enroll in future learning courses. Thus, the value of numeracy may be "that it opens the way to further learning opportunities…enabling people to progress to future education and training" (p. 239). Recently, Patterson and Paulson (2016) examined numeracy skills of adults who participated in the PIAAC Survey of Adult Skills and indicated participation in learning experiences, both formal and informal, in the last 12 months was positively related to numeracy skills. Therefore, the current literature suggests continual numeracy skill development and use pave the way for positive self-concept and meaningful learning engagement in educational experiences.

Current Investigation

The current investigation seeks to fill a gap in the existing literature. Many of the studies done to this point examine adults with experiences in numeracy programs who often possess the lowest level of numeracy skills. While Patterson and Paulson (2016) did investigate numeracy and learning in a large random sample, their focus was on learning both, formal and informal, and limited to activities in the past year prior to the survey. Since numeracy in these past studies has been shown to have positive educational outcomes, the current study seeks to extend this research by looking at the relationship of numeracy skills and formal learning qualifications in a large random sample of adults. Furthermore, the current study seeks to examine the relationship between persistence to a formal qualification after a uncompleted qualification. The research problem will explore if numeracy is related to commitment of adult learners in formal learning when controlled for other factors.

Methods

This study explored the relationship between numeracy and commitment to learning in adults in the United States. The data set selected was the OECD's PIAAC Survey Adult Skills' (2016) database. This section will outline the methodology utilized to explore the following research questions:

1. To what extent was numeracy ability related to a readiness to learn within formal and informal settings?
2. To what extent was numeracy ability related to the level of formal learning?
3. To what extent was numeracy ability related to quitting formal education?
4. To what extent was numeracy ability related to quitting and reentering formal education?

Data Source and Instrumentation

PIAAC is a large-scale international assessment directed by the OECD (2016). PIAAC administers the Survey of Adult Skills, which gathers individuals' levels of literacy, numeracy, and problem-solving in technology-rich environments (PSTRE), along with demographic and background information (OECD, 2016). PIAAC is a direct survey administered to individuals ages 16-74 in their homes. This on-going assessment was delivered in two cycles and a third future cycle is planned. The first round, from 2008-2013, involved 24 countries. The second, 2012-2016, expanded to an additional nine countries.

The current investigation will utilize data derived from the United States' sample from rounds 2012 and 2014, which consisted of 8,670 randomly selected individuals between the ages of 16-74. The sample was sufficient as "the effective sample size, which is the sample size needed to achieve the same sampling variance as a simple random sample, is 2,211" (OECD, 2016, pp. 1-181). Of the identified United States' population, 0.08% were excluded due to location barriers in their gated community (OECD, 2016, pp. 7-181). This is well within the bounds of the 5% non-inclusion rate established in the original data collection.

The non-response bias analysis showed fewer respondents who were 150% below the poverty level. Further analysis also showed the lowest response rates for the following groups:

> Hispanics age 26 and older, With no children in the household, Not living in the Northeastern United States, Living in segments with unemployment exceeding 4.8 percent, and Living in areas (Census tracts) with less than 5.1 percent of the population being linguistically isolated. (OECD, 2016, pp. 7-181)

Table 1.
PIAAC Expert Group Framework for Numerate Behavior

Numerate behavior involves managing a situation or solving a problem…

1. In a real context:
   -everyday life
   -work
   -society
   -further learning
2. by responding
   -identify, locate or access
   -act upon and use: order, count, estimate, compute, measure, model
   -interpret
   -evaluate/analyze
   -communicate
3. to mathematical content/information ideas:
   -quantity and number
   -dimension and shape
   -pattern, relationships, change
   -data and chance
4. represented in multiple ways:
   -objects and pictures
   -numbers and mathematical symbols
   -formulae
   -diagrams and maps, graphs, tables
   -texts
   -technology-based displays
5. Numerate behavior is found on the activation or several enabling factors and processes:
   -mathematical knowledge and conceptual understanding
   -adaptive reasoning and mathematical problem-solving skills
   -literacy skills
   -beliefs and attitudes
   -numeracy-related practices and experience
   -context/world knowledge

Note. Reprinted from OECD. (2016). Technical report of the survey of adult skills ([PIAAC], 2nd ed., pp. 2-7).

Table 2.
Final Numeracy Question Set Distributed by Context.

	Final item set	
	Number	%
Everyday life	25	45
Society and community	14	25
Further learning	4	7
Total	56	100

Note. Reprinted from OECD. (2016). Technical report of the survey of adult skills ([PIAAC], 2nd ed., pp. 2-26).

Table 3.
Final Numeracy Question Set Distributed by Cognitive Processes

	Final item set		Framework goal
	Number	%	Number
Act upon, use	34	61	50
Identify, locate or access	3	5	10
Interpret, evaluate	19	34	40
Total	56	100	100

Note. Reprinted from OECD. (2016). Technical report of the survey of adult skills ([PIAAC], 2nd ed., pp. 2-26).

Factors that favored a greater response rate were presence of children in the household, younger individuals ages 16-34, individuals with children 16 years and younger, and women. Equal probability sampling was used for dwelling units. Of the entire United States' sample, 98.9% the individuals who began the background questionnaire completed the assessments of numeracy, literacy, and PSTRE. The assessment was offered computer-based or with paper and pencil for individuals with limited computer experience. In the United States, of the 94.8% who completed the assessment, 79.9% completed the computer-based assessment, and 14.9% completed the paper-based assessment. The United States followed PIAAC procedures for addressing bias and variance. More information about the soundness of the sampling methodology can be located at https://www.oecd.org/skills/piaac/PIAAC_Technical_Report_2nd_Edition_Full_Report.pdf

The development of the PIAAC Survey began in 2008. Teams of experts developed the literacy, numeracy, and PSTRE framework, as well as the questionnaires and digital tools. The framework for numeracy was created to parallel the Adult Literacy and Life Skills Survey (ALL) in the area of numeracy. The assessment, a multistage-adaptive design, analyzed clusters of responses before offering the next test item and did not have any open-ended questions that required human scoring (OECD, 2016). "PIAAC was the first international comparative survey to include multistage adaptive testing as part of the Main Study" (OECD, 2016, pp. 1-12). Countries were tasked with "translation and adaptation of the master English language versions" of the surveys (OECD, 2016, p.12). A field test was conducted in 2010. Adaptions were made based on the field test, and the final version of the first-cycle main study was confirmed in 2011. Likewise, the second-cycle field test took place in 2013, and the main study began in 2014. An abbreviated outline of the validation of the instruments is provided below. More information about the field test and validation can be located at https://www.oecd.org/skills/piaac/PIAAC_Technical_Report_2nd_Edition_Full_Report.pdf

This study focused specifically on the numeracy framework and the background questionnaire; therefore, a more thorough description is provided regarding those areas. The numeracy framework was created using construct-centered approach consisting of four steps (Messick, 1994). First, an expert group defined and organized the domain so findings from the data could be distilled in meaningful ways. Table 1 outlines the framework for numerate behavior outlined by the expert group (OECD, 2016, pp. 2-7).

Based on these defined domains, tasks were identified that created the highest degree of authenticity combined with a variety of question types and levels. This included differing amounts of text in the question and a variety of response methods, such as drop-down, numeric entry, and click.

The numeracy question related to different contexts, cognitive processes, and content. Table 2 demonstrates the four contexts in which questions were embedded. The largest portion of the questions focus on everyday life, society, and community. The questions also require respondents to employ different cognitive processes.

Table 3 describes how the questions are distributed between less challenging and more challenging cognitive

Table 4.
Final Numeracy Question Set Distributed by Content

	Final item set		Framework goal
	Number	%	%
Data and chance	12	21	25
Dimension and shape	16	29	25
Pattern, relationships and change	15	27	20
Quantity and change	13	23	30
Total	56	100	100

Note. Reprinted from OECD. (2016). Technical report of the survey of adult skills ([PIAAC], 2nd ed., pp. 2-27).

Table 5.
PIAAC Numeracy Proficiency Levels.

Level	Literacy – Score	Numeracy – Score
Below level 1	0-175	0-175
1	176-225	176-225
2	226-275	226-275
3	276-325	276-325
4	326-375	326-375
5	376-500	376-500

Note. Reprinted from OECD. (2016). Technical report of the survey of adult skills ([PIAAC], 2nd ed., pp. 18-13).

applications of numeracy. The majority of the questions are upper-level application and evaluation processes.

The questions were also spread across the content that constitutes numeracy. Table 4 shows that the questions are relatively equally distributed among the four areas of the content framework.

Furthermore, an interpretive scheme for proficiency levels was established. Numeracy scores were reported across 6 levels on a 500 points scale. Table 5 displays these levels.

The assessment construction process and the questions' itemization demonstrate that the numeracy framework was well developed and constructed.

The background questionnaire (BQ) was carefully constructed and the data quality monitored. The BQ was developed to have multiple indicators of the same construct. Non-response bias assessment (NRBA) was required by all countries for inclusion in the data set. The following is in accordance with the OECD (2016):

> "[A] more extensive NRBA was required if the overall response rate was below 70%, or if any stage of data collection (screener, BQ, or the assessment) response rate was below 80%. An item NRBA was required for any BQ item with response rate below 85%" (pp. 16-25).

This study used several variables from the PIAAC data related to demographic information, level of education, education in the last 12 months, and one derived subscale. These variables were field tested in a previous round of data collection and were considered sound. The demographic information used included gender, ethnicity, and socio-economic status. For socio-economic status, the parents' education level, when the respondent was 16, was used, as it was identified as the strongest indicator by the PIAAC technical report (OECD, 2016).

Furthermore, the background questionnaire contained several subscales, including the readiness to learn subscale (OECD, 2016). During the field test, in order for a subscale to be retained in the PIAAC survey, three criteria were required: acceptable scale reliability (Cronbach's alpha > 0.6), non-redundant correlation (Mean correlation < 0.7) with other subscales, and no significant between-country differences (Weighted root mean squared difference (WRMSD) < 0.25) (OECD, 2016). The six questions, I_Q04b, I_Q04d, I_Q04h, I_Q04j, I_Q04l, I_Q04 on the readiness to learn subscale met two of these criteria (Cronbach's alpha > 0.85 and range of mean correlation -0.08 – 0.44) (OECD, 2016). However, while the construct did not quite meet the between-country differences' criteria (WRMSD < 0.41) other strengths of the other statistical evidence suggested it was a very reliable scale, so it was retained (OECD, 2016). More information regarding the development and validation of the variables for the study can be found at https://www.oecd.org/skills/piaac/PIAAC_Technical_Report_2nd_Edition_Full_Report.pdf

Table 6
Descriptive Data for Population Demographics

	N	Percent
Gender		
Male	4011	46.3
Female	4659	53.7
Ethnicity		
Hispanic	1101	13.0
White	5269	62.3
Black	1450	17.1
Other Race	641	7.6
Age		
16-24	2038	23.5
25-34	2100	24.2
35-44	1253	14.5
45-54	1301	15.0
55-65	1229	14.2
66 +	749	8.6
Highest Level of Education		
< High School	1404	16.1
High School	3636	41.9
Certificate	679	7.8
Associate Degree	630	7.3
Bachelor Degree	1310	15.1
Graduate Degree	796	9.1
Parents' Level of Education		
High School or Below	1431	17.9
Post-Secondary but No Graduate	3546	44.4
Graduate	3002	37.6

Note: Ethnicity had 209 missing cases; Highest Level of Education had 198 missing cases; Parents' Level of Education had 691 missing cases.

This study utilized the PIAAC Survey of Adult Skills' database. The data were accessed via the International Database Analyzer (IDA), then exported to SPSS for analysis.

Description of the Sample

The current investigation sought to analyze a sample of adults (*n*= 8670) in the United States between the ages of 16 - 74. Several demographic variables from the Background Questionnaire (BQ) were analyzed to describe the population, including gender (*n*= 8670), ethnicity (*n*= 8461), age (*n*= 8670), highest level of education (*n*= 8455), and parents' highest level of education (*n*= 7979). The descriptive summary for these variables is indicated on Table 6.

Methods Analysis

When examining the proposed research questions, a multivariate general linear model and chi-squared analyses were considered the most appropriate strategies. A multivariate general linear model is necessary due to the reporting of the numeracy scores through plausible values. The plausible values give a range of possible numeracy scores, on a normal curve, that are attributed to each individual. Thus, because individuals received multiple numeracy scores, using a multivariate general linear model was determined to be the most appropriate approach. These models are based on the following:

$$Y_i=\alpha + \beta x_i + \gamma D_i + \varepsilon_i$$

Where Y_i is the outcome for individual i, α is the y-intercept, βx_i is the product of the slope and the individual i's value, and γD_i is the product of the level of the variable and the individual's response, and ε_i is the error associated with individual i.

Results

The following results are presented specifically for each one of the four research questions. The research questions explored how numeracy related to adult learners' general readiness to learn, formal education attainment, and persistence in the formal education pathway. The following section explores the results discovered from the analysis of the data.

Research Question 1

Research question one sought to examine the relationship between the variables of numeracy and readiness to learn. Readiness to learn was a subscale derived and tested in the PIAAC assessment. The readiness to learn subscale reflected respondents' selections to questions regarding relation of new ideas to real life, partiality to learning new things, desiring to find solutions to difficult ideas, and exploration of how ideas fit together. The subscale created six categories of readiness to learn, which delineated the scores into the lowest 20%, more than 20% to 40%, more than 40% to 60%, more than 60% to 80%, and more than 80%.

The multivariate general linear model, or MANOVA, was used to compare the results of the readiness to learn variable with the plausible values for numeracy for each respondent. When examining the relationship, Hotelling's Trace was selected due to its robust application when samples' sizes are relatively equal (Hakstain, Roed, & Lind, 1979). Hotelling's Trace results are presented in Table 7.

The resulting η^2 indicates that there is a significant moderate effect of an individual's reported readiness to learn on their numeracy plausible scores.

A regression analysis was calculated to predict numeracy based on their level of readiness to learn. A regression analysis indicated F (5, 3976.62) = 58.63, p = .000, with an R^2 of .07, resulting in the following regression model:

$$Y_i = 199.16 + 18.90\,(\text{Low } 20\%) + 47.29(20\text{-}40\%) + 58.72(40\text{-}60\%) + 63.68(60\text{-}80\%) + 66.21(\text{more than } 80\%) + e_i$$

Research Question 2

Research question two sought to examine the relationship between the variables of numeracy and highest level of education. The highest level of education is described by six categories ranging from less than high school education to graduate degree.

A MANOVA was used to compare the response to the highest level of education variable with the plausible values for numeracy for each respondent. As indicated above, Hotelling's Trace was selected due to its robust application when samples sizes are relatively equal (Hakstain et al., 1979). Hotelling's Trace results are presented in Table 8.

Table 7
Readiness to Learn on Numeracy Score

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial η²
Intercept	34.36	23934.92	10.00	6966.00	0.00	0.97
Readiness to Learn	2.62	1.22	14950.00	69642.00	0.00	0.21

Table 8
Highest Level of Education on Numeracy Score

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial η²
Intercept	31.64	26701.91	10.00	8440.00	0.00	0.97
Highest Level	0.39	65.09	50.00	42192.00	0.00	0.07

Table 9
Descriptive Data for Completed or Uncompleted Formal Qualification

	N	Percent
Have had an uncompleted qualification	2075	23.9
Never have had an uncompleted qualification	4599	53.0

Table 10
Highest Level of Education on Numeracy Score for Dropout/Non-Completers

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial η^2
Intercept	22.08	14705.36	10.00	6660.00	0.00	0.96
Highest Level	0.004	2.65	10.00	6660.00	0.00	0.004

Table 11
Cross-Tabulation for Uncompleted Qualification and Highest Level of Education for Persistors

	Highest Level of Education				
	High School	Certificate	Associate	Bachelor	Graduate
Uncompleted Qualification					
High School	22	2			
Certificate		63	19	21	8
Associate			19	19	3
Bachelor				51	16
Graduate					73

The resulting η^2 indicates that highest level of education has a small, significant effect on the associated numeracy level of the individual.

A regression analysis was calculated to predict numeracy based on level of highest education. A significant regression analyses indicates F (5, 4002.9) = 267.88, p = .000, with an R^2 of .25, resulting in the following regression model:

$$Y_i = 208.07 + 36.23(\text{High School}) + 43.68(\text{Certificate}) + 59.39(\text{Associate}) + 81.12(\text{Bachelor}) + 92.30(\text{Graduate}) + e_i$$

Research Question 3

Research question three sought to examine the relationship between the variables of numeracy and dropping out or not completing a formal qualification. Descriptive statistics regarding individual persistence and demographic variables are presented in Table 9.

Thus, the multivariate general linear model was used to compare the response to the highest level of education variable with the plausible values for numeracy for each respondent. Once again, Hotelling's Trace was selected due to its robust application when samples sizes are relatively equal (Hakstian et al., 1979). Hotelling's Trace results are presented in Table 10.

The resulting η^2 indicates that .4% of the variance regarding uncompleted and completed formal qualification is likely associated with numeracy. A regression analysis was calculated to predict numeracy based on level of readiness to learn. The result was not significant.

Research Question 4

Research question four examined the relationship between the variables of numeracy and persistence to complete a degree after dropping out of a formal degree program. Therefore, this analysis only focused on those individuals who reported an uncompleted degree (n= 2072). A cross-tabulation in Table 11 provides the level of uncompleted qualifications reported by individuals and the highest level of education that the individual reported.

The result identified Persistors (n= 316) as adults who demonstrated commitment to learning by finishing an uncompleted degree, or a higher degree, than the uncompleted level, and the Non-persistors (n= 1746), as adults who dropped out of a formal education program and did not continue to complete a degree. A multivariate, general, linear model was used to compare the numeracy values for each respondent. Hotelling's Trace resulted in F(10, 2051) = 7.831, p= .000, η^2 = .037. The resulting η^2 indicates that persistence has a small, significant effect on the individuals' associated numeracy.

Discussion

This research study was conducted to determine the relationship between numeracy and adult learning readiness and commitment. This was accomplished through the examination of four research questions:

1. To what extent was numeracy ability related to a readiness to learn within formal and informal settings?
2. To what extent was numeracy ability related to the level of formal learning?
3. To what extent was numeracy ability related to quitting formal education?
4. To what extent was numeracy ability related to quitting and reentering formal education?

This section will interpret the findings, examine their relationship to existing research, and discuss implications of the study.

The first research question examined the link between numeracy abilities and readiness to learn. The readiness to learn subscale variable represented a variety of concepts that included the relating of new ideas to real life, partiality to learning new things, desire to find solutions to difficult ideas, and exploration of how ideas fit together. Often these skills are associated with learner cognitive patterns and, even more specifically, metacognition. Metacognition is a "consciousness of one's own learning or rational process; it is having an appreciation for the knowledge that you already have, knowing how and making room for the knowledge you do not have" and is a critical component to learning (Chekwa, McFadden, Divine, & Dorius, 2015, p. 109). Since much adult learning is self-directed, metacognition is particularly important because it is foundational to self-regulated learning (Azevedo, Moos, Johnson, & Chauncey, 2010; Winne & Hadwin, 2008). Previous research has shown that the construct of numeracy incorporates elements of the cognitive process (Condelli, 2006, p. 7; Maguire & O'Donoghue, 2002). The results of the present study further confirmed the link. When readiness to learn was compared with numeracy, a relationship existed between the two constructs. Thus, adult learners with higher numeracy skills are more apt to be ready to undertake learning experiences. Numeracy may be a construct that enhances adult learners' metacognition and other cognitive strategies, thus preparing them to monitor and regulate their self-directed learning.

The second research question explored numeracy abilities' relationship to level of education. These two variables were related, but the relationship was not strong. While it is not clear from the results if higher numeracy leads to the pursuit of more education or more education leads to higher numeracy, some relationship between the two elements exists. The literature is also mixed on the numeracy and education interaction (Adelman, 2006; Dion, 2014, Stewart, Lim, & Kim, 2015).

The third research question examined the relationship between numeracy abilities and dropping out of a formal qualification program. While there was a statistically significant relationship, there was no practical relationship between these two variables. One explanation for this is that dropping out or not dropping out of education may both be wise choices. If an adult's life circumstances are not conducive to investing in education at a specific time, they may choose to drop out for a phase, which is a wise choice (Comings et al., 1999; Comings, 2007, 2009). However, persisting in a linear fashion and not giving up despite difficult circumstances would also be considered a sound decision. Conversely, dropping out or persisting can be poor choices depending on the context of the decision. Because numeracy has been shown to correspond with better decision-making, one might expect that little difference would exist between the two groups, since individuals with high numeracy skills and low numeracy skills would be represented in both groups (Benjamin et al., 2013; French & Institute of Medicine (U.S.), 2014; Jasper et al., 2013; Pachur & Galesic, 2013; Peters, 2012; Peters et al., 2006). These data support that adults' skills and abilities may play a small factor in deciding what formal learning decisions are best, but adults' personal context, situations, and goals may have a larger impact on these decisions.

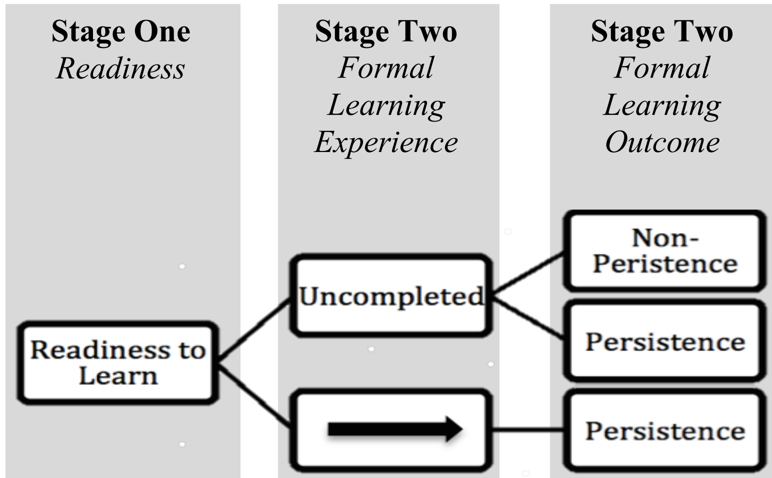
The final research question examined the relationship between numeracy ability and persistence. There was a small relationship between these variables. Thus, higher numeracy abilities may be a small part in commitment to learning. However, this relationship was not robust.

Summary

Finally, a holistic look at the findings yields patterns that need exploration. The pursuit of formal qualifications can be viewed as a pathway depicted in Figure 1. Stage One indicates learners in the state of readiness. Stage Two represents entrance and experience in formal education. Stage Three is the culminating outcome of the formal educational pathway.

Individuals begin with a specific level of readiness to learn in Stage One. Then, as individuals enter and begin their formal learning pathway in Stage Two, they either drop out and have an uncompleted degree, or they persist continuously to completion of a degree with no stop outs. Finally, in Stage Three the formal learning pathway ends in non-persistence or persistence. If the learners had an uncompleted degree in Stage 2 and never chose to re-enter the formal learning pathway, they would demonstrate non-persistence. However, learners who experienced an uncompleted formal pathway at a point in Stage Two and reentered Stage Two to complete the qualification would demonstrate persistence in Stage Three in spite of dropping out. Thus, this group could achieve a similar outcome to those that demonstrated persistence with no pauses in Stage 2 and moved continuously

Figure 1
Learning Cycle



through their formal education cycle. The process would then be repeated for each subsequent degree.

According to Comings et al. (1999), adults who completed a degree, regardless of the pathway taken, are persisting in education. Past research linking numeracy and the learning trajectory suggested that increased numeracy does create a pathway towards future learning (Maclachlan et al., 2009; Metcalf & Meadows, 2009). While the findings of the present study confirm that higher numeracy abilities have a strong relationship with adults' learning readiness, the relationship between numeracy and actual learning commitment was not as convincingly powerful as the previous studies. One possible reason is that the present study focuses on the learning pathway from high school all the way to graduate studies, and the previous studies were typically focused on a singular learning level such as a numeracy course that led to enrollment in more courses (Maclachlan et al., 2009; Metcalf & Meadows, 2009). Thus, the examination of the holistic pathway of learning readiness and commitment is unique to the current study.

The current study demonstrated that while numeracy had a large interaction at the readiness stage, that influence significantly decreases as readiness moves towards learning persistence decisions. Higher numeracy had a greater relationship in predicting beginning readiness than predicting learning actions, such as completing a degree without quitting (Stage 2) or persistence toward the end goal (Stage 3). The decrease of numeracy's role, when readiness (Stage 1) transforms into action in pursuit of learning goals (Stages 2 and 3), could be a reflection of the powerful influence of variables that are more important than ability (Boshier, 1973; Miller, 1967; Rubenson, 1977). These personal or systemic barriers located in the educational structure may outweigh abilities.

In light of these findings, numeracy and decision-making are not as tightly linked in education as in other behavioral economic fields. Education decisions may be unlike the behavioral economic decisions in healthcare and finance, both of which have demonstrated that numeracy and decision-making are highly related. Adults are immersed and shaped through the education process. The power of the social structures, both internal to the individual and external in the educational system, likely play a more powerful role than in medicine or finance where individuals interact on a more intermittent basis. Thus, a more complex combination of variables than just numeracy needs to be examined to understand adults' readiness and commitment to learning.

Implications for Practice

Educators at all levels, but particularly in the realm of K-12 schools, seek to instill the desire for lifelong learning in students. Educators recognize the importance of creating a mindset in the learners where they view themselves as active and curious information seekers who can make meaning of their own learning. The link between numeracy and readiness to learn manifests a tangible mechanism to help develop this skill. A focus on numeracy, not simply pure mathematics, within schools, has the potential to prime students towards a learning mindset. Thus, developing K-12 numeracy skills could have potential impact into adulthood learning endeavors. The benefits of a formal qualification have been extensively documented (Abel

& Deitz, 2014; Rose, 2013). Thus, encouraging numeracy development may be a potential factor to prepare learners to consider higher education when contemplated alongside other more personal and systemic factors for adult learners. However, before these results are acted upon, the connection between numeracy skills needs impact on education attainment need additional investigation to determine if higher numeracy abilities may cause higher levels of post-secondary attainment or vice versa. In the current investigation, the ability to explore this relationship further was not possible due to the use of an existing data set and lack of pre- and post-levels for individuals.

While numeracy may influence individuals' readiness, this influence on education-related decisions declines as readiness turns into persistence in a formal learning institution. Thus, it is conceivable that the relationship between numeracy abilities and educational decision-making becomes overshadowed by other internal and external factors that affect adult learning decisions (Boshier, 1973; Miller, 1967; Rubenson, 1977). Past literature has confirmed this effect in finding that factors such as life events and schedule are impactful predictors of learning activities (Johnstone & Rivera, 1965). Futhermore, Merriam, Caffarella, and Baumgartner (2006) contend, "Since the early 1990s the field of adult education has become much more conscious of the impact of sociocultural factors on shaping participation in adult education" (p. 68). Thus, findings in past literature and the decreased impact of numeracy abilities from learner readiness to formal education persistence in this study suggest this area warrants further exploration of barriers to adult learning.

External barriers such as the structure of schooling may be a compelling factor in uncompleted degrees and non-persistent learners. Thus, two lines of research could be examined. First, future research could replicate this study using data from different countries whose education systems are dissimilar to those of the United States and thus could provide some new insights. Second, future research could entail a closer examination of the demographic, internal, and external demographic variables that define the group of adult learners who are committed to learning with a particular focus on first-generation students. These studies would further reveal the degree to which social factors influence an environment of success for adult learning.

Further study should also examine the link between numeracy abilities and level of education. Due to the lack of access to pre- and post-data in the current study, the connection between numeracy and education could not be further explored to determine which variable was causing the other to increase. It is recommended that future research should examine the numeracy abilities in a longitudinal study that follows individuals through numerous levels of education rather than at a single point in time.

Limitations

The limitations of this analysis arise from the use of an existing data set. The second research question could not be fully explored due the lack of pre- and post-assessment data. Furthermore, the lack of access to participants does not allow for follow-up for further quantitative and qualitative data collection that could add additional depth to the findings. Finally, the use of the existing data set confined the additional investigation that was performed to the variables and data that had been previously collected.

Summary

Education is a vehicle that allows adults to construct industrious lives and be involved, productive citizens in society. Their learning can be informal or lead to acquisition of formal qualifications, but, regardless, the path is self-directed by the learner. The adult learner carefully balances personal ambitions with the forces with which they contend to reach their final goal. Thus, to better understand adult learners, we must understand the factors that affect their education-related decision-making process.

In the United States, education beyond high school involves investments of personal and financial resources. Similar cost-benefit analyses occur when adults interact with medical or financial decisions. In these venues, personal behaviors, such as knowledge, beliefs, and values, distort pure economic decisions. In the fields of medicine and finance, a link has been found between adult numeracy abilities and decision-making. Thus, in the current study, numeracy abilities were explored to examine their link in educational decision-making.

While numeracy had a statistically significant relationship with the variables, other variables on the relationship—readiness to learn, level of education, completion of a degree with no hiatuses, and persistence to complete a qualification after dropping out of a formal learning program—were sizeable. Additionally, a holistic pattern emerged that demonstrated a significantly stronger direct relationship between numeracy and readiness to learn than at either of the intersections where learners made persistence-related decisions. While numeracy skills were shown to matter in education decisions, they did not solely capture the complex factors that are predictive of adults' education pathways. This trend suggests the needed future analysis of other variables.

Insights gained through this project added to the pool of evidence that the United States education system, P – 16 and beyond, has social and cultural barriers that restrain some adults from obtaining the highest degrees of education. While numeracy did not play a practical role in propelling adults along their learning pathway, there was a strong relationship with adult learning readiness. This finding supports the development of numeracy skills, not just pure mathematics skills, at all levels of education in order to increase cognitive readiness of learners.

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KAREN H. LARWIN, Ph.D**.**, earned her doctorate from Kent State University in Evaluation, Measurement, and Applied Statistics in 2007. She currently serves as an Associate Professor at Youngstown State University in the Counseling, School Psychology, and Leadership department. Her theoretical research has primarily focused on the use of technology to understand and enhance the learning experience for all learners. Her methodological research focuses on meta-analytic procedures and structural equation modeling applications. Dr. Larwin is credited for developing a statistical application, SIR-SEM, that is used for systematic item elimination within structural equation modeling. Dr. Larwin serves as a chair for the American Evaluation Association Quantitative Methods section, and as the chair of the YSU Institutional Review Board.

JENNIFER L. HOLLINGER, Ed.D**.**, earned her doctorate from Youngstown State University in Educational Leadership in 2018. She currently is an Assistant Professor of Education at the University of Mount Union. Dr. Hollinger teaches courses in curriculum planning, mathematics teaching methods, and special education. Dr. Hollinger's research focuses on strategies in both P-12 education and in higher education that will allow institutions to best serve the diverse needs of all students.