NUMERACY AND ADULTS' LEARNING READINESS AND COMMITMENT: RESULTS FROM A LARGE NATIONAL RANDOM SAMPLE OF PARTICIPANTS

by

Jennifer Hollinger

Submitted in Partial Fulfillment of the Requirements

for the Degree of

ED. D

in the

Educational Leadership

Program

YOUNGSTOWN STATE UNIVERSITY

May 2018

NUMERACY AND ADULTS' LEARNING READINESS AND COMMITMENT: RESULTS FROM A LARGE NATIONAL RANDOM SAMPLE OF PARTICIPANTS

Jennifer Hollinger

Signature:

_____

Jennifer Hollinger, Student Date

Approvals:

_____

Dr. Karen Larwin, Thesis Advisor Date

_____

Dr. Patrick Spearman, Committee Member Date

_____

Dr. M. Kathleen L. Cripe, Committee Member Date

_____

Dr. Susan Horne, Committee Member Date

_____

Dr. Salvatore A. Sanders, Dean of Graduate Studies Date

Abstract

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. Since 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 Programme for the International Assessment of Adult Competencies (PIAAC) Survey Adult Skills. The findings suggest numeracy abilities are positively related to readiness to learn and learning commit. Further analysis demonstrated a relationship between parents' education level and learning commitment. Implications of the study suggest that social and cultural capital from family background impact adult learning persistence. Thus, multigenerational educational support must be considered in tandem with basic skill interventions for adult learners.

Acknowledgements

The pursuit of my doctoral degree and completion of my dissertation would not have been possible without the support of my professors, colleagues, friends, and family.

I am grateful for the support and guidance of my chair, Dr. Karen Larwin. With your constant encouragement, you made my goals attainable and pushed me to be even better each step of the way. To my committee, thank you for the time each of you invested in support of my work and helping me grow as a researcher and writer.

To my cohort, we have become such a great team over the last three years. We have supported each other as professionals and friends! I cannot wait to see what the future holds for each of us.

To my colleagues and friends, thank you for speaking words of encouragement to me through each step of my process. Without each of you, I would have never dreamed to even take the first step towards my degree, but with you by my side I have accomplished it.

To my family, while you may have not helped write words on the pages of this dissertation, you are the inspiration and provision that provided the ability to compose every word. Thank to my parents, who have been an extra set of hands to support our busy family whenever needed. Thank you to my husband, Bryan, who has been a constant encourager, cheerleader, and support system. To my children, Lauren, Findlay, Jace and Naomi, I hope you have learned how to work hard and dream big. Our family journey over the last three years has taught us to trust in God to provide our needs and sustain us through all things. Together, we have learned that our strength comes from him and the completion of this dissertation is confirmation of his enduring faithfulness.

Table of Contents

Chapter 1

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 learning does not always occur in a smooth, linear fashion. Temporary pauses in the 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 pace of adult learning is a choice. Therefore, to understand an adult's commitment to partake and persist in learning experiences, the decision-making process to initiate learning, exit learning, and reengage in learning must be explored.

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). Since 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.

Since 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 seems like an unlikely indicator of behavioral economic decision, 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 them 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. Researchers, primarily in the fields of medicine and finance, have further 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.

Problem Statement

In this vein, it would be prudent to know if numeracy is related to learning readiness and commitment. Existing studies linking adult learning and numeracy often examine adults' experiences in numeracy programs rather than level of numeracy skills. These studies suggest that learners in numeracy programs gain self-confidence and are more likely to enroll in future courses (Maclachlan, Tett, & Hall, 2009; Metcalf & Meadows, 2009). Metcalf and Meadows (2009) contended that numeracy may be the key that opens doors to future education (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 in the last 12 months. Their findings suggest that those individuals with higher numeracy scores were more likely to partake in recent learning experiences (Patterson & Paulson, 2016). Their work concluded by suggesting that more research is needed in the area of numeracy and learning. Thus, the current investigation will address the gap in the literature related to numeracy levels and adults' commitment to learning. The research problem will explore if numeracy is related to commitment of adult learners when controlled for other factors.

Nature of the Study

This quantitative study utilized data collected through the PIAAC Survey of Adult Skills. The numeracy and background questionnaire information from the United States

sample was analyzed. Data were exported from the International Database Analyzer (IDA) to SPSS for investigation. The research questions explored using descriptive statistics and inferential statistics. Regression analysis was used to examine relationships within the data.

Research Questions and Hypotheses

Past research related to numeracy suggests that higher numeracy leads to more sound decision-making across multiple contexts. Therefore, this research sought to investigate the hypothesis that if an individual has high numeracy abilities, then they will understand the value of education and be more committed to learning. This study explored the following research questions to explore this hypothesis.

1. To what extent is numeracy ability related to a readiness to learn?
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?

Purpose of the Study

Traditional measures imply that adult learning persistence is a well-documented problem. The majority of adult learners do not persevere to attain their degree despite the positive future prospects related to degree completion (Bergman, Gross, Berry, & Shuck, 2014; Choy, 2002; Davidson & Holbrook, 2014). Kasworm (2008) reported that although adults are motivated by personal goals when returning to formal education, lack of congruence between their learning environment and their personal confidence leads toward failure. Personal, dispositional, social, economic, and academic factors can also

have an effect on adult learners' commitment to learning (Boeren, Nicaise, & Baert, 2012; McGivney, 2004; Windisch, 2016). While these risk factors are known, many are dynamic, unforeseeable, beyond one's control, and change over the duration of the learning experience. Thus, finding a predictor of adult learning persistence that is more stable and can be manipulated to build learner confidence, academic skills, and social capital would be an important contribution to education.

Numeracy has the potential to predict commitment to learning. The overlap between numeracy and decision-making has been extensively explored in the areas of medicine and finance (Benjamin, Brown, & Shapiro, 2013; French & Institute of Medicine (U.S.), 2014; Jasper, Bhattacharya, Levin, Jones, & Bossard, 2013; Pachur & Galesic, 2013; Peters, 2012; Peters et al., 2006). Education is a similar behavioral economics' construct. Current research, in the field of numeracy and education, demonstrates that adolescents' math experiences and scores are predictors of success in post-secondary education (Adelman, 2006; Harwell, Moreno, & Post, 2016; Rose, 2013). Therefore, the purpose of this study is to determine if numeracy relates to adult commitment to learning. Since many of the other adult learner risk factors are beyond the control of an institution, adult numeracy could be a stronger predictor of at-risk students and be utilized to retain adult learners.

Theoretical Base

Adult learning theory proposes that both internal and external forces influence the motivation and methodology of adult learners (Boshier, 1973; Knowles, 1968; Miller, 1967; Rubenson, 1977; Tough, 1979). The summation of these forces will influence the persistence of adults towards conquering their learning goals. Tough (1979) and

Knowles (1968) both recognized that adults are internally motivated. Thus, adults partake in self-directed learning that is influenced by life experiences, personal needs, and social roles. Additionally, theory suggests that adults weigh the expectation of success in relation to their investment as they decide to commit to learning (Rubenson, 1977). Miller's (1967) Force Field Analysis Theory weighed the interaction of internal and external environment. The theory proposes that when negative forces, either internal or external, outweigh the positive, learners will not engage or persist in learning. Boshier's (1973) Congruence Model presented an example of the impact of an external force. The theory suggests that congruence between the adult learner's self-concept and the learning environment determine persistence. Adult learning and motivation theory provide an understanding of the adult learner's decisions by describing the relationship between both internal and external forces. Numeracy, a concept that encompasses cognitive skills and processes, beliefs, and social context may be a variable that can capture a depiction of these forces and be utilized as a predictor of adult learning readiness and commitment.

Definition of Terms

Adult Learning – "self-directed learning, the freedom to choose, to be a good consumer of educational products, to become involved or not depending on personally interpreted need" (Courtney, 1992, p. 17).

Commitment to Learning – "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" (Comings, Parrella, & Soricone, 1999, p. 3).

Numeracy – "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" (PIAAC Numeracy Expert Group, 2009, p. 21).

Assumptions

This section will outline the assumptions of the study. First, the assumption must be made that the PIAAC Survey of Adult Skills is an accurate measurement. Additionally, it must be assumed that individuals provided accurate information on the background questionnaire and performed to the best of their ability on the numeracy assessment. Finally, all data are assumed to be independent, normally distributed, and possess homogeneity of variance.

Limitations

The limitations of this study stem mainly from response bias, self-reporting, and pre-existing data. Trochim and Donnelly (2008) asserted that social science researchers must always consider, "the realities of human interaction and its effect on the research process" (p. 171). The PIAAC survey was done one-on-one in peoples' homes. Response bias, a social interaction threat, could arise as the respondent is influenced by their interactions with the interviewer. Therefore, individuals may not have responded honestly in order to impress or please the interviewer. Also, data derived from self-reporting may contain error, not just because of response bias, but rather from inaccurate or incomplete information provided in error. These threats to internal validity have some potential to lead to incorrect assumptions regarding the data. Finally, the use of a pre-existing data set limits the study parameters to the variables and data collected.

Delimitations

Due to the large, diverse sample collected for the PIAAC survey, delimitations are not expected. The PIAAC data collection was thorough in providing a representative sample. The sample size of 8,670 individuals is also quite large. The methods to which the data were extracted ensured that a representative sample of scores were provided for each individual (OECD, 2016). The use of inferential statistics generally requires that the researcher follow the assumptions of independence, normal distribution, and homogeneity of variance. However, due to the strong design of the instrumentation and data collection techniques, these delimitations are not expected to cause threats to external validity.

Summary

The following study examined if there is a relationship between numeracy and commitment to learning. The overview demonstrates that adult learning perseverance is a problem and there is value in adult commitment to life-long learning. Furthermore, numeracy may be a predictor because of its multi-faceted nature and its established link to more sound decision-making. The next section will provide a comprehensive review of literature surrounding the topics of numeracy, adult learning and decision-making.

Chapter 2

Literature Review

Numeracy

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. There are many interpretations of what numeracy entails, but across most characterizations four themes emerge: content, cognitive processes, dispositions, and context. This section will explore each aspect of numeracy.

Content

A high level of agreement exists about what information constitutes numeracy content. Program for International Student Assessment ([PISA] OECD, 2013) an international assessment given to secondary students, and PIAAC, an international assessment given to adults, are two well-established test frameworks utilized internationally. PISA and PIAAC, while offered to different subsets of the population, hold a high correlation of content agreement. A comparison between these international assessments and the National Council for Teaching Mathematics ([NCTM], 2017) K-12 standards allows the comparison of international numeracy content frameworks and North American numeracy content viewpoints. While, NCTM's focus and membership is in the United States and Canada, they are the world's largest mathematics focus organization (NCTM, 2017). Figure 1 compares the constructs of the NCTM Standards,

Ginsburg, Manly, & Schmitt (2006)	PIAAC (2009)	PISA (OECD, 2013)	NCTM (NCTM, 2017).
Number and Operation Sense	Quantity and Number	Quantity	Number and Operations
Patterns, Functions, and Algebra	Pattern Relationships and Change	Change and Relationships	Algebra
Measurement and Shape	Dimensions and Shape	Space and Shape	Geometry; Measurement
Data, Statistics, and Probability	Data and Change	Uncertainty and Data	Data and Probability

Figure 1. Alignment PIAAC, PISA, and NCTM with Ginsburg, Manly, & Schmitt (2006) numeracy content framework

PISA, and PIAAC. This comparison utilizes the framework of Ginsburg's, Manly's, & Schmitt's (2006) study which compared many numeracy frameworks and created four classifications of adult numeracy content:

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

PIAAC, a newer assessment of numeracy, was not included in Ginsburg et al.'s (2006) initial study, but as demonstrated by Figure 1, has complete alignment with the four established categories. The number and operation sense category encompass the idea of quantity and number operations. More specifically, Ginsburg et al. suggested number sense consists of relationships between numbers, understanding relative size and multiple representations, computation, and operations in real-world settings. The PISA frameworks describe number sense content as the “most pervasive and essential mathematical aspect of engaging with, and functioning in, our world” (OECD, 2013, p.

34). This is likely because, this content is "important in building the intuition and reasoning necessary for flexible thinking and for understanding concepts in other strands" (Ginsburg et al., p. 14). Therefore, number sense and operations are the building blocks for other numeracy content.

The Patterns, Functions, and Algebra category extends number sense by examining change and relationships in multiple ways. Ginsburg et al. (2006) defined algebra to include common representations, such as modeling, structures, representations, and more sophisticated mathematical formats, such as functions. Often the term algebraic reasoning is used in place of algebra to illustrate the idea that algebra is more than a body of knowledge and an active way of thinking and interacting with concepts of patterns and relationships (Kaput, Carraher, & Blanton, 2008). Kaput et al. (2008) further described this thinking as both symbolic thinking, which is syntax-focused, and representation thinking, which is mental processes-focused.

The Data, Statistics, and Probability category requires learners to correctly interpret and analyze numerical situations. Unlike most numeracy content that focuses on precision and accuracy, this category focuses on evaluating situations with uncertainty. Often this is describe in the literature as data literacy, or "the ability of adults to describe populations, deal with uncertainty, assess claims, and make decisions thoughtfully" (Ginsburg et al., 2006, p. 18). In essence, this content seeks to make critical thinkers who can analyze the large quantity of information present in today's society.

The Measurement and Shape category explores relationships by comparing and

contrasting different representations of two-dimensional and three-dimensional shapes. This investigation of shapes includes analysis of shape components, such as angles and lines, as well as, direct and indirect measurement of shape quantities. From reading maps to constructing houses, shape and measurements have a strong application in real-life (Ginsburg et al., 2006; Ojose, 2011). The concepts of measurement and shape overlap with other numeracy content. They provide visual representation of numbers' sense and display algebraic patterns.

Numeracy content can be categorized; however, the boundaries are not clean breaks between the groupings. Thus, a broad understanding of numeracy content is important. However, numeracy content must also be understood with both breadth and depth. Ginsburg et al. (2006) suggested that, "Numeracy skills do not stop at 'being good with numbers.' Numeracy for the twenty-first century is a much richer construct." (p. 19). In fact, NCTM, PISA, and PIAAC frameworks identify cognitive processes related to numeracy along-side the content categories. Therefore, the next section will explore how individuals make meaning of numeracy content.

Cognitive Processes

A cognitive process is a way that individuals acquire and make meaning of new knowledge (Garner, 2007). The original explanation of numeracy in the Crowther's report held a high level of cognitive sophistication (Ministry of Education, 1959). The report described numeracy "as an understanding of the scientific approach to the study of phenomena - observation, hypothesis, experiment, verification" and "to think quantitatively, to realize how far our problems are problems of degree even when they

appear as problems of kind" (Ministry of Education, 1959, p. 270). However, cognitive numeracy processes increase in complexity from simple knowledge of basic proficiency skills to more complicated thinking where skills are applied, and judgments are made.

Condelli (2006) outlined a three-level numeracy cognitive process framework, which was developed during Maguire's and O'Donoghue's (2002) presentation at the International Conference for the Adult Learning of Mathematics. The model begins with the Formative Level where numeracy is a routine replication of basic arithmetic. Evans, Waite, and Admasachew (2009) called this the limited proficiency model, which requires simple recall, no application, and a very low level of cognition.

Maguire's and O'Donoghue's (2002) second level, the Mathematic Level, described numeracy as simple use of basic skills embedded in every day context (Condelli, 2006). This application requires a higher cognitive demand as individual make decisions and judgments based on numeracy knowledge. "In this phase, numeracy often includes number, money, and percentages; aspects of algebraic, geometric, and statistical thinking; and problem solving based on the mathematical demands of adult life" (Condelli, 2006, p. 7).

Finally, the Integrative Phase portrays numeracy as "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). This production, or creation, with numeracy requires a higher level of cognition.

Maguire's and O'Donoghue's (2002) model suggested that numeracy content can be defined not just by lists of mathematical content but also by the level of cognitive thought processes. However, growing 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 that "The formal activity of learning mathematics at any stage of life is intimately bound up with the identity of the learner" (p.13). Thus, a disconnect between skill level and cognitive level can be the cause of negative impact on a learner's identity.

Dispositions

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, & National Research Council (U.S.), (2001) defined disposition as:

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 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 require 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). Thus numeracy, a rich concept embedded in the social environment, moves to a context-free mathematical notion.

Context

Numeracy is such a valuable life skill because it 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). 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). Ginsburg et al. (2006) further suggested "there can be no debate as to its value, both for an individual's full participation in today's society and for a nation's development of its democratic potential" (p. 41). The connection of context to individuals' interpretation of numeracy situations and their associated interactions with society is vital to defining numeracy, particularly in adults who have rich and pervasive connections to society.

Importance

The importance of numeracy goes beyond fluent mathematical skills. 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). Maclachlan, Tett, & Hall (2009) examined adult learners in basic numeracy and literacy programs and found these programs increased not only knowledge, but also learner self-confidence and social capital. Metcalf and Meadows (2009) likewise discovered that

increased numeracy skills, among other factors such as achieved qualifications and newfound independence, had a positive effect on individuals' confidence and self-esteem. Recently, Patterson and Paulson (2016) demonstrated that adults with higher numeracy skills were more likely to participate in learning experience in the 12 months prior to being surveyed.

Adults who lack literacy and numeracy skills also have an "increasing risk of marginalization and social exclusion" (Bynner & Parsons, 2009, p. 29). 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 et al. (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). Therefore, continual numeracy skill development and use are foundational for meaningful life engagement.

Adults as Learners

Today more than ever before, education must extend beyond childhood and young adult years. Cross (1992) suggested,

> The learning society is growing because it must. It would be difficult to think of some way to live in a society changing as rapidly as ours without constantly learning new things. When life was simpler, one generation could pass along to the next generation what it needed to know to get along in the world; tomorrow

> was a simply a repeat of yesterday. Now, however, the world changes faster than the generations, and individuals must live in several different worlds during their lifetimes. (p.1)

Consequently, adults must view themselves as lifelong learners and commit to pursuing educational opportunities through all stages of their lives.

Adult learning occurs both formally and informally. Often, adults learn by, "freely going about the business of learning in the context of the business of life" (Courtney, 1992, p. 17). Learning is, consequently, self-directed, deepening the knowledge of the individual in a personal area of need (Courtney, 1992). However, adults also learn from more formal education and training experiences. Adult education is typically defined by "attendance at classes, certification, and the authority of experts"(Courtney, 1992, p.17). Regardless of the formality of the learning mechanism, adult learning is a choice; unlike childhood learning, no level of attendance, participation, or persistence is required. Thus, research surrounding what motivates adults to undertake the demands of learning began to develop as a field of study separate from the study of child and young adult learners.

Adult Motivation and Learning Theory

Until relatively recently, learning theory made no delineation between how adults and children learn. However, in the 1960s and 1970s research began to examine the different internal and external forces that influence the adult learner. Five notable models offer insight into the complex learning interactions of adults. These models, Self-Directed Learning (Tough, 1979), Expectancy–Valiancy Paradigm (Rubenson, 1977), Theory of

Adult Learning (Knowles, 1968), Force Field Analysis (Miller, 1967), and the Congruence Model (Boshier, 1973), will be examined in this section.

Tough's (1979) work focused on the self-directed nature of adult learners. Tough's (1979) model of Self-Directed Learning, contends that, "the learner's conscious anticipation of reward is more important than subconscious forces or environmental forces" (Cross, 1992). Thus, Tough (1979) suggested that an adult learner understands why they should undertake learning and will manage their learning on their own.

Rubenson's (1977) Expectancy and Valiancy Model also focuses on the internal dynamics of each learner. Expectancy in the model is described in two equal parts: the expectancy of success and the expectancy that success will yield positive consequences. The theory views these parts as multiples of one another. Thus, if one is zero, such as a learner has no belief that they can be successful, there will be a zero in the expectancy portion of the model, regardless of the belief that positive outcomes are possible. In the model, valiancy considers the positive and negative impacts to the individual if learning is pursued. A positive could be a pay increase; a negative could be the cost of the training or education. This model has a strong focus on factors internal to the learner similar to Tough's (1979) model of Self-Directed Learning.

Much like Rubenson (1977) and Tough (1979), Knowles (1968), explored the adult learners motivations from the internal learner perspective. Knowles (1968) Theory of Adult Learning outlines five main principles.

1. Adult learners are self-directed; the more mature a person is the more self-direct their learning becomes.
2. Adult learners draw on their life experiences as a resource for learning.

3. Adult learners' needs adjust as their social roles change.
4. Adult learning is problem-centered with immediate context for application.
5. Adults display internal motivation; they are not externally motivated.

While the worthiness of these principles has not been debated, some debate exists around this theory. First, many recognized the value of these teaching assumptions for all learners not just adults. Knowles (1978) agreed suggesting that his principles may in fact describe learner-directedness for any age and not just outline learning in adulthood. Additionally, others suggested that these did not equitably describe learning even across all adults. Since adults do not pursue learning in isolation, theories such as Rubenson's (1977), Tough's (1979), and Knowles' (1968) failed to account for external forces that affect adult learning choices. Specifically addressing Knowles' Adult Learning Theory, Merriam (2001) stated,

> Based in humanistic psychology, Knowles's version of andragogy presents the individual learner as one who is autonomous, free, and growth oriented…There is little or no acknowledgment that every person has been shaped by his or her culture and society, that every person has a history, and that social institutions and structures define, to a large extent, the learning transaction irrespective of the individual learner. (p. 7)

Thus, an exploration of adult learners is not complete unless we consider these external forces.

Society and history are undoubtedly external forces affecting adult learning choices. Thus, our vision of adult learning would be incomplete without focusing on the

external environment in addition to the individual learner. Education is not neutral and can either empower or continue to oppress the learner. Therefore, learners may not be self-directed until they are freed from the oppression of the societal context (Freire, 1970). Thus, to have a culturally relevant view of adult learners, we must look at adult learning theories that address not just the internal dialogue of the learner, but the external tensions of the environment.

Miller (1967) combined aspects of Maslow's (1943) hierarchy of needs with Lewin's (1947) positive and negative forces to develop the theory of Force Field Analysis which examines motivation of adult learners. Miller's (1967) theory sought to clarify motivation, expected outcomes, and demographic differences particular across socioeconomic status. Miller suggested there is a relationship between education, age, and life stage. In early adulthood, education is focused on obtaining the security that comes with employment. Later on, in adulthood, once basic needs are met, adults can use learning as a method to reach self-actualization. However, Miller's (1967) model suggested that negative forces can prevent persistence in learning despite the value and access of the learning opportunity. Even if learners possess strong internal motivation and other positive forces, Miller (1967) proposed that internal and external negative forces, when they outweigh the positive, can prevent learners from engaging, or derail persistence for learners already involved.

Boshier's (1973) Congruence Model also identified external influences on the learner that impacted their willingness and motivation to engage in learning. The Congruence Model suggested the compatibility between the learner and the learning

environment was a determining force in learner persistence. Boshier (1973) suggested

> Both adult education participation and dropout can be understood to occur as a function of the magnitude of the discrepancy between the participants self-concept and key aspects (largely people) of the education environment. Nonparticipants manifest self/institution incongruence and do not enroll. (p. 260)

On the other hand, learners who experience congruence may constantly want more. They may become almost addicted to learning particularly later in life (Manheimer, 2002; Mehrotra, 2003).

Recent studies provide evidence that many adult learners do not persevere to attain their degree despite the positive forces and outcomes that are possible (Bergman et al., 2014; Choy, 2002; Davidson & Holbrook, 2014). Kasworm (2008) suggested a cause is the lack of congruence and personal confidence. Furthermore, personal, dispositional, social, economic, and academic factors can have a cumulative effect on adult learners' commitment to learning (Boeren, Nicaise, & Baert, 2012; McGivney, 2004). Therefore, more investigation is needed into the complex process that drives adult learning commitment.

Adult Learning Commitment

Comings' (2009) redefinition of adult learning commitment was clearly influenced by both the internal and external forces affecting the adult learner. Persistence in adult education is less about continuous enrollment and more about continuous learning until the learner's personal goal is reached (Comings, 2009). Often adult learners stop formal learning for a period of time but still view themselves as active in the program and plan to return as soon as they are able (Comings, 2007; Windisch, 2016).

Thus, external forces may affect formal learning for a season, but committed individuals will still persist in learning in time, although informally through self-study. Therefore, when examining adult learning decisions and motivation, commitment to learning must be considered holistically, rather than solely examining episodes of withdrawal from formal education. The decision to partake in adult learning is a complex interaction of internal and external forces. Learners elect when to initiate learning, exit learning, and reengage into learning. Therefore, to truly understand adults' commitment to learning, one must understand adults as decision makers.

Decision-making

Decision-making and knowledge are inextricably tied together. Individuals use understanding of facts, opinions, and beliefs surrounding situations combined with personal goals to make decisions (von Winterfeldt, 2013). The essence of decision-making seems to integrate both the understanding about specific events and peoples' subjective reactions to those events (Oliveira, 2007). Decision-makers combine these sources of information by considering past and potential outcomes (Oliveira, 2007).

Economic decisions are those that involve the cost-benefit of investing in situations (Wolla, 2013). This investment includes consideration of not only physical capital, but also human capital since "skills of the workforce are an important source of economic growth" (Bernanke 2007, para. 4; Wolla, 2013). However, individuals rarely make purely economic decisions. Therefore, the field of behavioral economics integrates economics with psychology and sociology to gain clarity into human decision-making (Koch, Nafziger, & Nielsen, 2015). Pure economics would suggest a stability in the decision-maker, but in reality, behavioral economists have found that since decisions are

not made in a vacuum, people have non-standard reactions based on their personal emotions, the influences, or priming, from environmental cues that sway later behavior, and the perspective with which the situation is presented, or framed (DellaVigna, 2009). Thus, economic decisions are strongly influenced by an individual's knowledge, beliefs, and context.

Since numeracy integrates individuals' cognitive abilities, personal disposition, and the social context, researchers have begun exploring the relationship between numeracy and decision-making. Clemen and Gregory (2000) contended that numeracy skills allow adults to carefully consider uncertain choices. Other research, mainly in the fields of medicine and finance, focuses on decision-making outcomes and found that individuals with higher numeracy possess better judgment, superior risk analysis, and demonstrate patience.

Numeracy and Decision-Making

Numeracy skills have been linked to better judgment in decision-making situations. Peters et al. (2006) found that when presented with number-based decision-making scenarios, individuals with high levels of numeracy were better able to access and apply appropriate concepts. Additionally, elevated numeracy skills produce better judgment because individuals are less susceptible to priming and framing (Choi, Wong, Mendiratta, Heiman, & Hamberger, 2011; Peters, 2012; Peters et al., 2006). When dealing with decisions surrounding health care and personal finance, individuals must process scientific or mathematical information. Numerous studies have demonstrated that when given health information graphically or statistically highly numerate individuals made more sound decisions (Brown et al., 2011; Keller & Siegrist, 2009; Wong et al.,

2012). In the health field, higher numeracy also has been shown to lead to more accurate general information processing (Hawley et al., 2008; Schachter, Tharmalingam, & Kleinman, 2011). Similarly, in the financial sector, higher numeracy leads to wiser choices regarding debt and investment (Agarwal & Mazumder, 2013; Banks, O'Dea, & Oldfield, 2011). Estrada-Mejia, de Vries, & Zeelenberg (2016) suggested that high numeracy, more than other factors such as risk-tolerance, cognition, or financial knowledge, had a positive effect on wealth.

An individual's ability to better translate numerical information also affects their decisions regarding strategic risk. Jasper et al. (2013) suggested that poor risk analysis may be because individuals with lower numeracy skill struggled to extract relevant information, and therefore took more unprofitable risks. In the health sector, countless studies revealed that more numerate individuals made strategically better treatment choices (Pachur & Galesic, 2013; Schwartz, 1997). In one study of patients admitted to the hospital, those with high numeracy, despite other demographic factors, were four times more likely to seek hospital care within the first hour of their medical episode (Petrova et al., 2017). The financial industry has similar results suggesting individuals who are less numerate take more imprudent risks (Bateman et al., 2016). This may be because lower numeracy was associated with less knowledge about financial investing and the stock market (Lusardi, Mitchell, & Curto, 2009). Likewise, Ashby (2017) concluded that less numerate individuals explore fewer options when considering decision outcomes.

More numerate individuals spend more time contemplating decisions leading to wiser choices. Benjamin, Brown, and Shapiro, (2013) reported that individuals with

higher numerical ability possessed great patience and were able to choose delayed gratification over instantaneous rewards. Meyer et al. (2007) showed that when adults made decisions about health treatments, those with higher cognitive ability considered their treatment longer before making decisions. A connection between patience and numeracy has also been found in children. Children's inhibitory control, or ability to regulate behaviors, has been shown to be positively correlated to mathematic abilities (Blair & Razza, 2007; Merkley, Thompson, & Scerif, 2016). In economic settings, high numeracy has been shown to associate with less impulsive consumer behavior and with more forward-thinking financial decisions (Nye & Hillyard, 2013). Deliberation, or delay, for even just a small amount of time is important to allow the brain to identify the most significant information and, in turn, make better decisions (Teichert, Ferrera, & Grinband, 2014).

Summary

While much of the behavioral economic research focuses on medical and financial decisions, from a personal economic perspective, "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) . Often, education decisions require consideration of large-financial investments and cost-reward scenarios. Commitment to further education also requires a personal risk assessment and a willingness to persevere, remain patient, and delay gratification. The research literature establishes a clear link between numeracy and the types of factors individuals may consider when contemplating educational opportunities. However, few studies have examined adult numeracy skills and individuals' decisions to pursue learning over a lifetime. The following section will

outline the methodology to be used to examine the relationship between numeracy and commitment to learning.

Chapter 3

Methods

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

1. To what extent is numeracy ability related to a readiness to learn?
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 chapter will describe the proposed participants, instrumentation, and procedures that were used in the current investigation. In addition, the chapter will provide details regarding the PIAAC population and sample, validity and reliability of instrument, the variables, procedures, and data analysis methodologies.

Participants

PIAAC is a large-scale international assessment directed by the OECD. 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 16-65 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.

This study utilized data derived from the United States' sample from rounds 2012 and 2014 to analyze relationships between numeracy and commitment to learning. The sample for the study was 8,670 randomly-selected individuals from the United States between the ages of 16-74 years. 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)

Factors that favored a greater response rate were: presence of children in the household, younger individuals, 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 paper and pencil for individuals with limited computer experience. In the United States, 79.9% of the respondents 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

Instrumentation

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

Since this study focused specifically on the numeracy framework and the background questionnaire, 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. Figure 2 outlines the framework for numerate behavior outlined by the expert group (OECD, 2016, pp. 2-7).

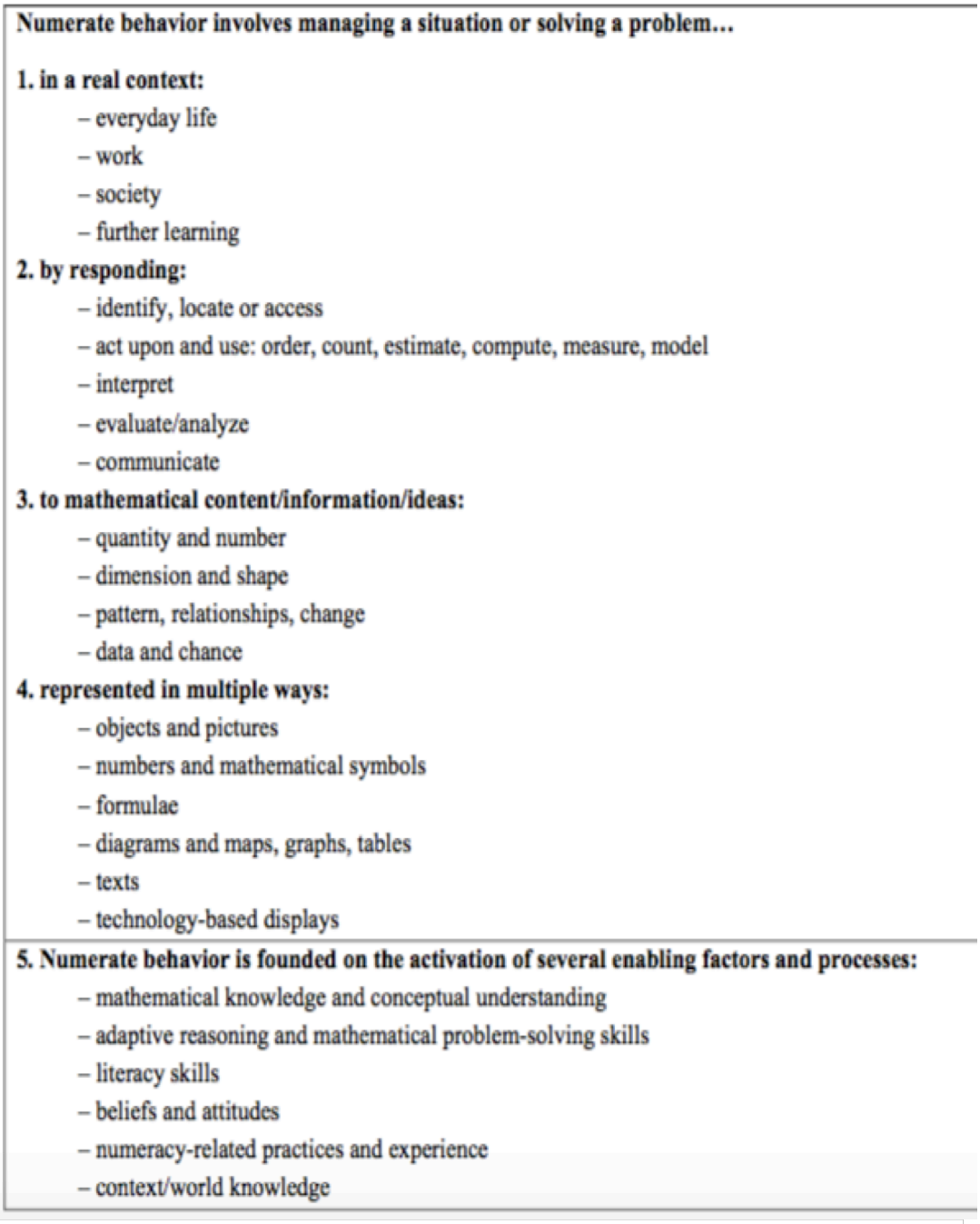

Figure 2. PIAAC Expert Group Framework for Numerate Behavior. Reprinted from OECD. (2016). Technical report of the survey of adult skills ([PIAAC], 2nd ed., pp. 2-7).

Based on these defined domain, 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. Figure 3 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.

	Final item set	
	Number	%
Everyday life	25	45
Work-related	13	23
Society and community	14	25
Further learning	4	7
Total	56	100

Figure 3. Final numeracy question set distributed by context. Reprinted from OECD. (2016). Technical report of the survey of adult skills ([PIAAC], 2nd ed., pp. 2-26).

Figure 4 describes how the questions are distributed between less challenging and more challenging cognitive applications of numeracy. The majority of the questions are upper level application and evaluation 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: Each category includes continuous, noncontinuous and combined texts.

Figure 4. Final numeracy question set distributed by cognitive processes. Reprinted from OECD. (2016). Technical report of the survey of adult skills ([PIAAC], 2nd ed., pp. 2-26).

The questions were also spread across the content that constitutes numeracy. Figure 5 shows that the questions are relatively equally distributed among the four areas of the content framework.

	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

Figure 5. Final numeracy question set distributed by content. OECD. Reprinted form (2016). Technical report of the survey of adult skills ([PIAAC], 2nd ed., pp. 2-27).

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

Figure 6. PIAAC Numeracy Proficiency Levels. Reprinted from OECD. (2016). Technical report of the survey of adult skills ([PIAAC], 2nd ed., pp. 18-13).

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. According to 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.

Furthermore, the background questionnaire contained several subscales which were tested, 13 of which were maintained. For the purpose of this study, one of those subscales, Readiness to Learn, was analyzed (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 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

Procedures

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.

Data Analysis

The research questions were explored using descriptive statistics. The data was investigated using multivariate general linear test and chi-squared analysis. A general linear model was selected due the reporting of the numeracy scores through plausible values, which yields multiple numeracy scores for each individual. The multivariate general linear test was used to examine the effect of the independent variables on the dependent variables in the questions related to numeracy abilities. A regression analysis was also used to examine relationships within the data. Furthermore, the chi-squared analysis was used to test for relationships within the categorical variables when parents' education level and learning persistence variables were explored.

Chapter 4

This study analyzed the PIAAC Survey of Adult Skills. The PIAAC's rigorous assessment development and data collection processes have yielded a valid and robust data set. The data collection consisted of a background questionnaire (BQ), delivered via an interviewer who then remained present as the individuals took assessment tests in numeracy, literacy, and computer-based problem solving. The skills' assessments were delivered in an adaptive test format, which was found to be, "15 to 47 percent more efficient" (OECD, 2016, p. 6). The large-scale assessment was also carefully developed to triangulate with prior adult skill assessments. An extensive field test demonstrated the soundness prior to the PIAAC's initial round of data collection. During the initial collection of the randomly-selected United States sample, only 0.08% were excluded due to location barriers, which was well within the bounds of the 5% non-inclusion rate established for the original data collection (OECD, 2016, pp. 7-181). In addition, 98.9% the individuals who began the background questionnaire completed the assessments of numeracy, literacy, and problem-solving in technology-rich environments. Thus, a total of 8,670 respondents were used for the sample of this study. The following chapter will outline the statistical analyses used to explore relationships between numeracy and adult learning.

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 1.

Table 1. *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 has198 missing cases; Parents' Level of Education had 691 missing cases.

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, since individuals received

multiple numeracy scores, using a multivariate general linear model was determined to be 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.

The following section contains the analysis for each of the four research questions that the study set out to answer.

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 relating new ideas to real life, partiality to learning new things, desire to find solutions to difficult ideas, and exploring 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 relationship, Hotelling's Trace was selected due to its robust application when samples sizes are relatively equal (Hakstain, Roed, & Lind, 1979). Hotelling's Trace resulted in $F(14950, 69642) = 1.222$, $p < .001$, $n^2 = .208$. The

resulting n^2 indicates that 20.8% of the variance in readiness to learn is associate with numeracy.

Furthermore, data were depicted on a scatterplot to further inspect the relationship. The positive relationship between readiness to learn and numeracy is displayed by the scatterplot in Figure 7.

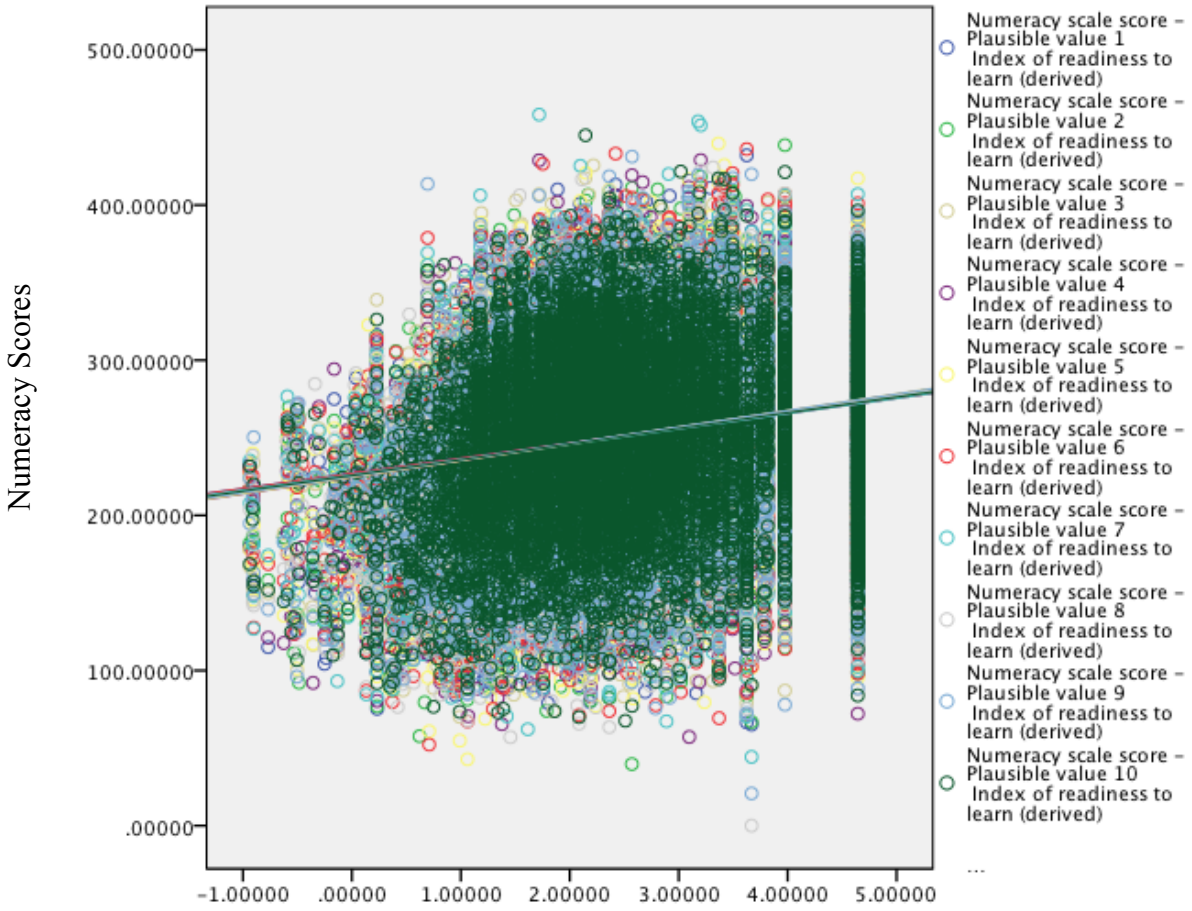

Figure 7. Plausible numeracy values compared with readiness to learn subscale values.

A regression analysis was calculated to predict numeracy based on their level of readiness to learn. A regression equation was found (F (5, 3976.62) = 58.63, $p < .001$), with an R^2 of .07. Resulting in the following regression equation:

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

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 resulted in a value F (50, 42192) = 65.086, $p < .001$, $n^2 = .072$. The resulting n^2 indicates that 7.2% of the variance in level of education is associate with numeracy.

Furthermore, data were depicted on a scatterplot to further inspect the relationship. The positive relationship between higher qualifications completed and numeracy is displayed by the scatterplot in Figure 8.

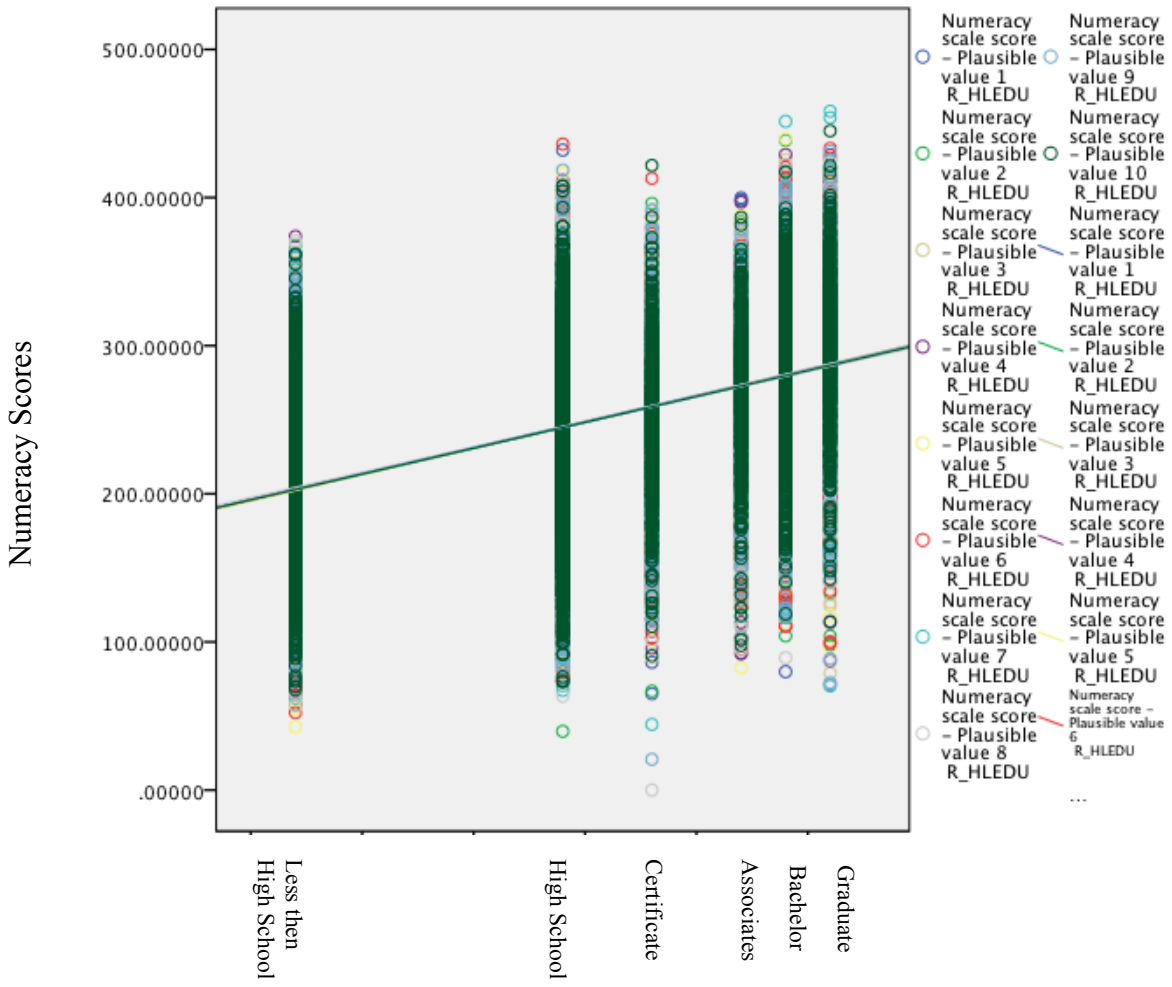

Figure 8. Plausible numeracy values compared with the highest level of formal education

A regression analysis was calculated to predict numeracy based on their level of readiness to learn. A significant regression equation was found (F (5, 4002.9) = 267.88, p < .001), with an R^2 of .25, resulting in the following regression equation:

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

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 statics regarding individual persistence and demographic variables are exhibited in Table 2.

Table 2. *Descriptive Data for Completed or Uncompleted Formal Qualification*

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

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 resulted in $F(14950, 69642) = 2.651$, $p < .05$, $n^2 = .004$. The resulting n^2 indicates that .4% of the variance regarding uncompleted and completed formal qualification is likely associate with numeracy.

Furthermore, data were depicted on a scatterplot to further inspect the relationship. The graph in Figure 9 demonstrates that no there is no relationship between completing or not completing a formal qualification and numeracy.

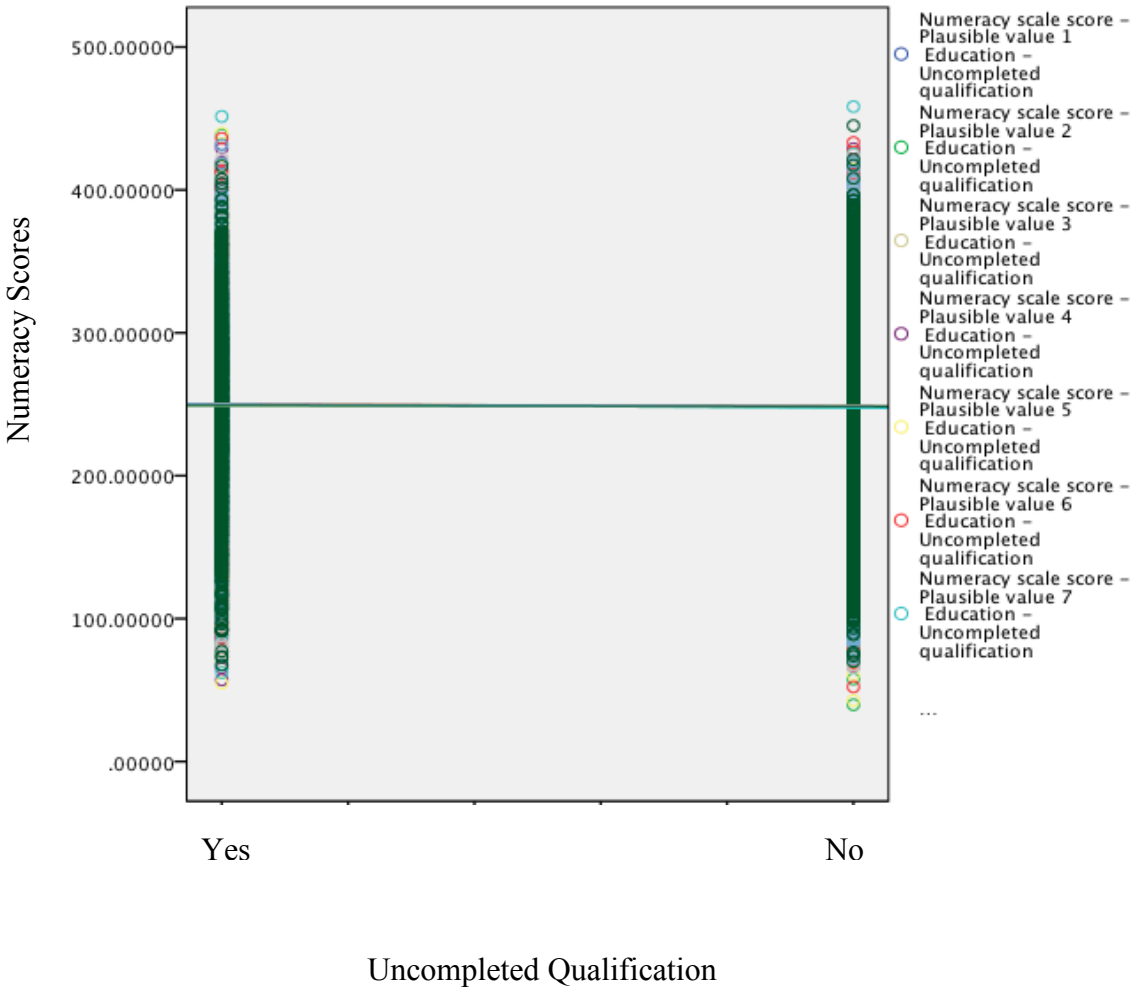

Figure 9. Plausible numeracy values compared with uncompleted qualification.

A regression analysis was calculated to predict numeracy based on their level of readiness to learn. The result was not significant.

Research Question 4

Research question four sought to examine the relationship between the variables of numeracy and persisting to complete a degree after dropping out of a formal degree program. Therefore, just the data for individuals who reported an uncompleted degree (*n*= 2072) were analyzed for this question. Thus, a cross-tabulation is shown in Table 3

between 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 Non-persistors (*n*= 1746), as adults who dropped out of a formal education program and did not continue on to complete a degree.

Table 3. *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

A multivariate general linear model was used to compare the numeracy values for each respondent. Hotelling's Trace resulted in $F(10, 2051) = 7.831$, $p < .001$, $n^2 = .037$. The resulting n^2 indicates that 3.7% of the variance in persistence is associate with numeracy.

Furthermore, data were depicted on a scatterplot to further inspect the relationship. The slight, but not practically significant relationship between levels of persistence and numeracy is displayed by the scatterplot in Figure 10.

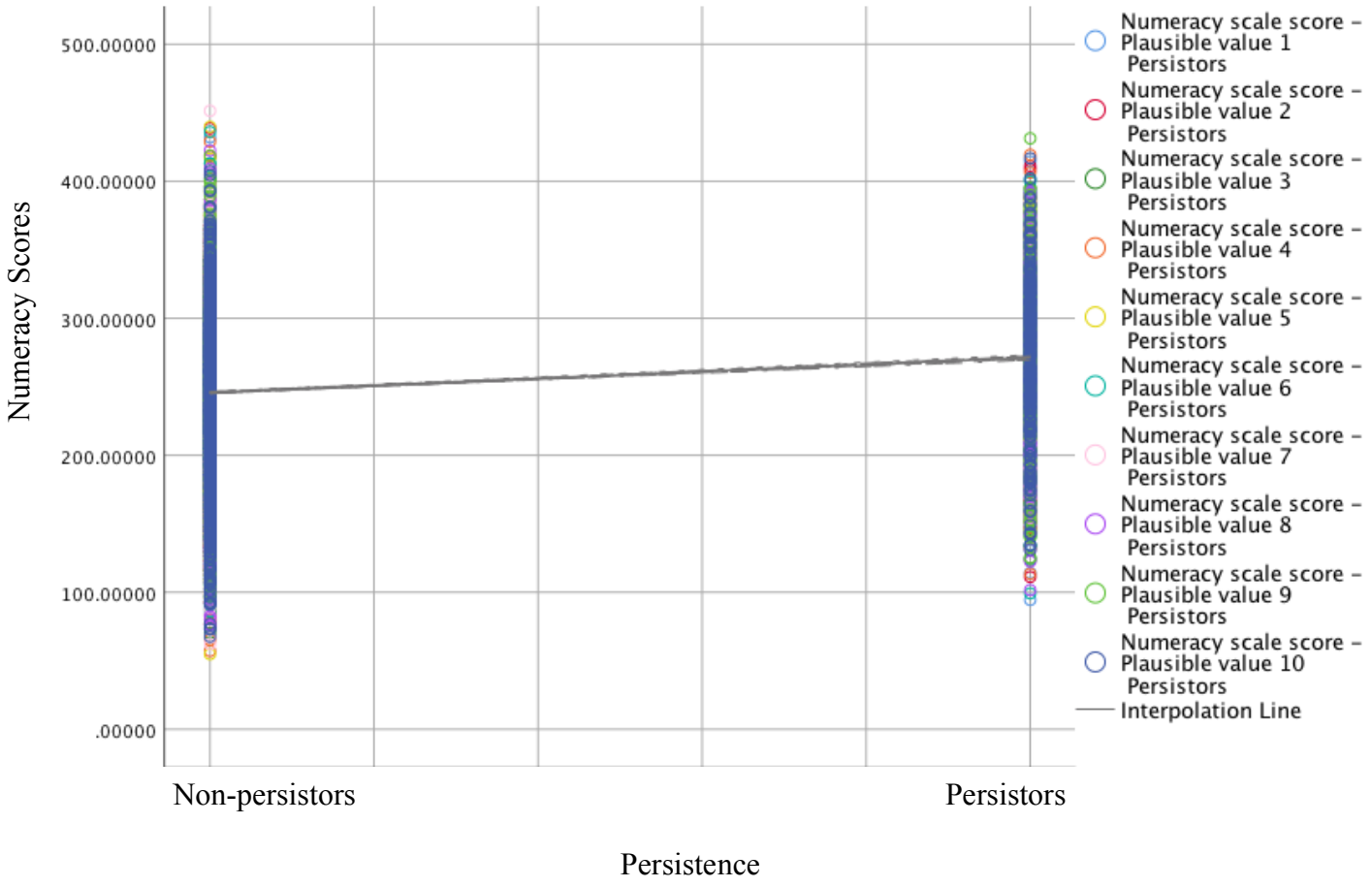

Figure 10. Plausible Numeracy Values Compared with Persistence or Non-persistence

In light of a statistical, but not practical significant relationship between numeracy and persistence, further analysis was completed. The highest level of parents' education was explored using a chi-squared test to examine Persistors and the Non-persistors in relation to their parents' highest level of education. The results revealed χ^2 (2, n = 1928) = 6.596, p< .05. Thus, a relationship does exist between persisting in learning and parents' level of education. This relationship is depicted in Figure 11.

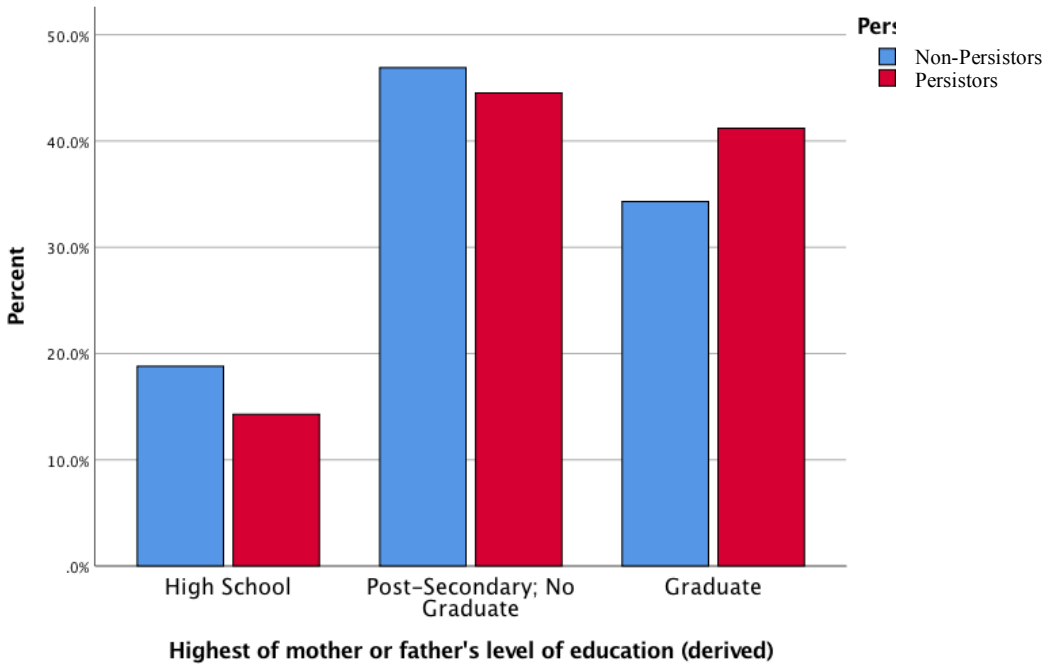

Figure 11. Level of Parents' Education and Persistence versus Non-persistence

Furthermore, for the group of adults who persisted in learning (n= 301), parents' highest level of education was examined alongside the dropout point and final highest level of education. The results of the chi-squared revealed χ^2 (4, n = 301) = 317.05, p< .001 showing a statistically significant relationship between parents' education level and the individual persistence level after dropout. Furthermore, this strong correlation between parents' education level and persistence level was depicted graphically in a series of bar graphs in Figure 12.

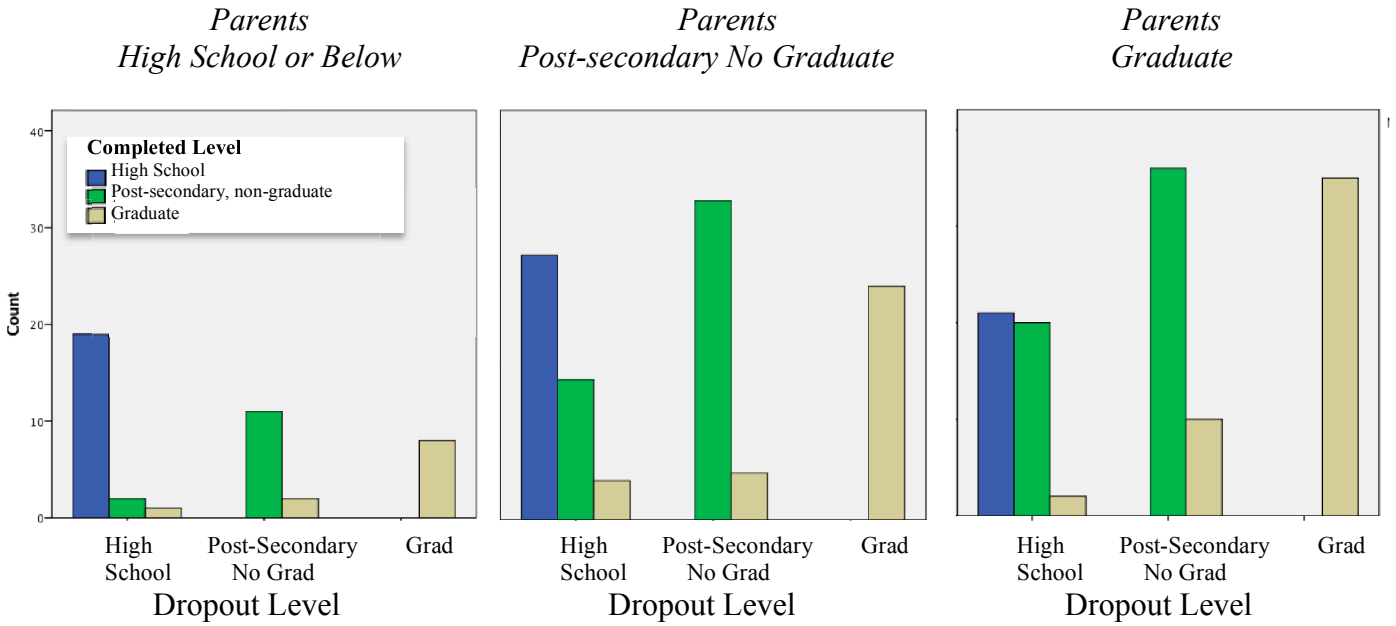

Figure 12. Level of Parents' Education and Level of Persistence

Summary

Overall, the results suggest that numeracy ability does have a relationship with aspects of adult learning. Adults' readiness to learn had a strong positive correlation with numeracy. The readiness to learn subscale included ideas related to cognitive processes employed in learning, which would prepare an individual to take part in a learning environment. There was a statistically significant, but not a practically significant, relationship between numeracy and an uncompleted formal qualification or persistence following an uncompleted qualification. Therefore, further analysis was carried out which examined other factors associated with commitment to learning. Numeracy, and the variable, highest level of parents' education, showed a significant relationship. The implications of these results will be further explored in the next chapter.

Chapter 5

This research study was conducted to determine the relationship between numeracy and adult learning readiness and commitment. A national dataset was selected to ensure a large representative sample, sound instrumentation, and robust data collection techniques. Quantitative analysis techniques were used to investigate the research questions. This chapter will interpret the findings, examine their relationship to existing research, and discuss implications of the study.

Discussion of Results

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 relating new ideas to real life, partiality to learning new things, desire to find solutions to difficult ideas, and exploring 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 critical component to learning (Chekwa, McFadden, Divine, & Dorius, 2015, p. 109). Since adult learning is self-directed, metacognition is particularly important as 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 with

numeracy were compared, 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 learner metacognition and other cognitive strategies 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 also is mixed on the numeracy and education interaction (Dion, 2014, Adelman, 2006; Stewart, Lim & Kim, 2015). Before these results are acted upon, the connection between numeracy skills needs further investigation to determine if higher numeracy abilities may cause higher levels of post-secondary attainment or the other way around. 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.

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. Since 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, Brown, & Shapiro, 2013; French & Institute of Medicine (U.S.), 2014; Jasper, Bhattacharya, Levin, Jones, & Bossard, 2013; Pachur & Galesic, 2013; Peters, 2012; Peters et al., 2006). These data support that adults make learning decisions that are best for their personal context, situations, and goals, skills, and abilities may be a very small factor in that evaluation.

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. In light of this, further exploration revealed the importance of considering parents' education level in adult learning persistence. The parents' education variable not only captured the highest formal qualification attainment of the mother or father, but also was recommended for use as an indicator of socioeconomic status by the PIAAC framework (OECD, 2016). Parents' education level revealed a relationship to persistence and non-persistence of those who quit learning. Even more dramatic was the relationship between parents' education level and the highest education level attained by those who quit formal learning, but reentered and persisted to attain a formal qualification. The pattern supports similar findings from other studies, which have defined a link between economic and cultural capital related to family background and

learning attainment (Davis-Kean, 2005; Dubow, Boxer, & Huesmann, 2009; Ma, Pender, & Welch, 2016).

Finally, a holistic look at the findings yields patterns that need exploration. If the pursuit of formal qualification were viewed as a pathway depicted in Figure 13, the progression would begin with Readiness to Learn (Stage 1). Then, as individuals began their learning pathway, they would either continue straight to completion or drop out and have an uncompleted degree (State 2). Finally, the path either culminates with non-persistance after dropout, or persistence towards the learning goal without dropping out, or in spite of a drop out (Stage 3). The process would then be repeated for each subsequent degree.

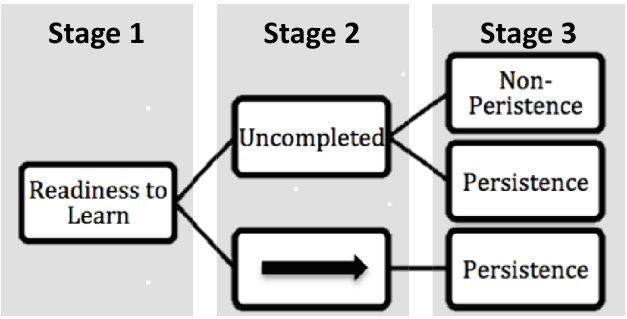

Figure 13. Learning Cycle

According to Comings (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 (Metcalf & Meadows, 2009; Maclachlan et al., 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 learn pathway from high school all the way to graduate studies, and the previous studies were typically focused on a singular learning level such as numeracy course that led to enrollment in more courses (Metcalf & Meadows, 2009; Maclachlan et al.). 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 then 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. The extended data analysis completed in the current study supports this conclusion. A strong link was found between adults' learning persistence after an uncompleted degree and parents' highest level of education, a variable that encapsulates both socio-economic status and educational family experiences. Moreover, in the group of adults who persisted despite dropping out of a formal degree program, parents' education level was strongly related to the level of education attained by these adult learners. This suggests that adults

are influenced by the patterns of educational experiences in their family and may even be influenced to persist beyond this based on aspirations of betterment.

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 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 of Findings

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 benefit of a formal qualification have been extensively documented (Rose, 2013; Abel & Deitz, 2014). Thus, encouraging numeracy development may be a potential factor to prepare learners to

consider higher education when considered alongside other more personal and systemic factors for adult learners.

While numeracy may largely 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). The parental education level, an external factor, captures both a reflection of an adult's childhood socio-economic status and their family's experience interacting with the education environment. The strong impact presented in the study of parents' education on their adult children's education trajectory provides strong support of family engagement in K-12 and higher education. Sticht (2012) stated, when discussion literacy skills that, "focus on a single life cycle fails to recognize the key role that the education of adults plays in the transfer of literacy from one generation to the next" (p. 63-64). Furthermore, this sentiment was shared by Dion (2014) suggesting that, "Adults who do not feel that they are good at math – an attitude that often dates back to their own experiences in school – may normalize poor numeracy skills and pass low expectations on to their children, perpetuating a culture in which strong numeracy skills are not valued" (p. 6). Education, in general, seems to follow the similar vein. Thus, a multigenerational education intervention and increased school family engagement might be necessary.

Social Reproduction Theory ascribes this multigenerational association to the congruence of the individual's social and cultural capital with the schooling system

(Bourdieu, 1986; Giroux, 1983). Thus, educational systems become perpetuators of the dominant culture, and learners who are not part of the dominant cultural experience disconnection (Freire, 1970; Serna, 2015). Additionally, parent aspirations, or education vision for their children, can impact education attainment (Attanasio & Kaufmann, 2009; Foley, Gallipoli, & Green, 2014). In the K-12 setting, supporting family roles and engagement are the norm. However, with independent adult learners, family interactions look much different, but may be just as important for commitment to learning.

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.

Recommendations

The decreased interaction between numeracy readiness and numeracy persistence is an area that warrants further exploration. 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, a replication of this study using data from different countries whose education systems are dissimilar to those of the United States could provide some new insights. Second, a closer examination of the 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 reproduction theory, combined with parents' aspirations, create environments 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 explored further to determine which variable was the 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.

Additionally, since education attainment across generations impacts learning commitment, numeracy may also be a factor across these generations. Studies typically view numeracy abilities as a variable isolated to an individual. However, since numeracy contains elements of cultural context promoted in families, an examination of multigenerational numeracy may yield understanding that could not be studied through isolated case analysis. Thus, a multigenerational numeracy study, which also considered internal and external demographic variables, could yield important information in promoting better decision-making in education. Moreover, since medical history and financial wealth also span generations and have a correlation to numeracy, further research could provide new information in these areas.

Conclusion

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 their personal ambitions with the forces that they must contend with 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, Readiness to Learn, level of education, completing a degree with no hiatuses, and persisting to complete a qualification after dropping out of a formal learning program, on the Readiness to Learn relationship was 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. This trend influenced further analysis of other variables. The variable parents' education was selected as it not only reflected the highest degree held in the learner's immediate family, but also was reflective of their childhood socioeconomic status. For the adults who reported an uncompleted qualification, parents' education not only demonstrated their likelihood to persist and finish the uncompleted qualification, but also revealed a strong relationship to the highest level of education that they would

complete. Thus, the analysis confirmed that complex internal and external factors affect adult learners and have a powerful impact on their learning pathway.

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. Since educational systems and values vary across the cultures, numeracy abilities may show varying impact on education decisions across different contexts. Furthermore, as the study and past research has revealed, education decisions, even in adult life are influenced by multigenerational factors. Thus, future work should consider the abilities of the family structure rather than isolating skills of individuals.

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 between adult learning readiness. This finding supports the development of numeracy skills, not just pure mathematics skills, at all levels of education to increase cognitive readiness of learners. These skills can easily be embedded in existing school structures and may function to support learners. Furthermore, these outcomes suggest that a strong multigenerational connection exists in learning pathways. Thus, social and cultural capital, passed on from parents, shape education even into adulthood. Therefore, the effectiveness of skill-related interventions will always be moderated by other internal and external forces that exist within the educational pathways of adult learners.

References

Abel, J. R., & Deitz, R. (2014). Do the benefits of college still outweigh the costs? *Current Issues In Economics & Finance*, *20*(3), 1–12.

Adelman, C. (2006). The toolbox revisited: Paths to degree completion from high school through college. *US Department of Education*. Retrieved from https://eric.ed.gov/?id=ED490195

Agarwal, S., & Mazumder, B. (2013). Cognitive abilities and household financial decision making. *American Economic Journal: Applied Economics*, *5*(1), 193–207. https://doi.org/10.1257/app.5.1.193

Ashby, N. J. S. (2017). Numeracy predicts preference consistency: Deliberative search heuristics increase choice consistency for choices from description and experience. *Judgment & Decision Making*, *12*(2), 128–139.

Attanasio, O., & Kaufmann, K. (2009). *Educational choices, subjective expectations, and credit constraints*. Cambridge, MA: National Bureau of Economic Research.

Azevedo, R., Moos, D. C., Johnson, A. M., & Chauncey, A. D. (2010). Measuring cognitive and metacognitive regulatory processes during hypermedia learning: Issues and challenges. *Educational Psychologist*, *45*(4), 210–223. https://doi.org/10.1080/00461520.2010.515934

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215.

Banks, J., O'Dea, C., & Oldfield, Z. (2011). Cognitive function, numeracy and retirement saving trajectories. *The Economic Journal*, *120*(548), F381–F410. https://doi.org/10.1111/j.1468-0297.2010.02395.x

Bateman, H., Eckert, C., Geweke, J., Louviere, J., Satchell, S., & Thorp, S. (2016). Risk presentation and portfolio choice. *Review of Finance*, *20*(1), 201–229. https://doi.org/10.1093/rof/rfv001

Benjamin, D. J., Brown, S. A., & Shapiro, J. M. (2013). Who is "behavioral"? Cognitive ability and anomalous preferences: Who is "behavioral"? *Journal of the European Economic Association*, *11*(6), 1231–1255. https://doi.org/10.1111/jeea.12055

Bergman, M., Gross, J. P. K., Berry, M., & Shuck, B. (2014). If life happened but a degree didn't: Examining factors that impact adult student persistence. *The Journal of Continuing Higher Education*, *62*(2), 90–101. https://doi.org/10.1080/07377363.2014.915445

Bernanke, B. S. (2007). "Education and economic competitiveness." Presented at the U.S. Chamber Education and Workforce Summit, Washington, D.C. Retrieved from https://www.federalreserve.gov/newsevents/speech/bernanke20070924a.htm

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*(2), 647–663. https://doi.org/10.1111/j.1467-8624.2007.01019.x

Boeren, E., Nicaise, I., & Baert, H. (2012). Adult learners' satisfaction and its relation to characteristics of the individual and the educational institution. *Pedagogies: An International Journal*, *7*(2), 132–149. https://doi.org/10.1080/1554480X.2012.655887

Bong, M., & Skaalvik, E. M. (2003). Academic self-concept and self-efficacy: How different are they really? *Educational Psycology Review*, 1–40.

Boshier, R. (1973). Educational participation and dropout: A theoretical model. *Adult Education*, *23*(4), 255–282.

Bourdieu, P. (1986). The forms of capital. In J. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241–258). New York, NY: Greenwood.

Brown, S. M., Culver, J. O., Osann, K. E., MacDonald, D. J., Sand, S., Thornton, A. A., … Weitzel, J. N. (2011). Health literacy, numeracy, and interpretation of graphical breast cancer risk estimates. *Patient Education and Counseling*, *83*(1), 92–98. https://doi.org/10.1016/j.pec.2010.04.027

Bynner, J., & Parsons, L. (2009). Insight into basic skills form UK longitudinal study. In S. M. Reder & J. M. Bynner (Eds.), *Tracking adult literacy and numeracy skills: Findings from longitudinal research* (1st ed., pp. 27–58). New York, NY: Routledge.

Chekwa, E., McFadden, M., Divine, A., & Dorius, T. (2015). Metacognition: Transforming the learning experience. *Journal Of Learning In Higher Education*, *11*(1), 109–112.

Choi, H., Wong, J. B., Mendiratta, A., Heiman, G. A., & Hamberger, M. J. (2011). Numeracy and framing bias in epilepsy. *Epilepsy & Behavior*, *20*(1), 29–33. https://doi.org/10.1016/j.yebeh.2010.10.005

Choy, S. (2002). *Findings from the conditions of education 2002: Nontraditional undergraduates*. Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Clemen, R., & Gregory, R. (2000). Preparing adult student to be better descision makers. In Y. Gal (Ed.), *Adult numeracy development: Theory, research, practice* (pp. 73–86). Cresskill, N. J: Hampton Press.

Comings, J. P. (2007). Persistence: Helping adult education students reach their goals. In *Review of adult learning and literacy* (Vol. 7, pp. 23–46). Cambridge, MA: National Center for the Study of Adult Learning and Literacy.

Comings, J. P. (2009). Student persistance in adult literacy and numeracy programs. In S. M. Reder & J. M. Bynner (Eds.), *Tracking adult literacy and numeracy skills: Findings from longitudinal research* (1st ed., pp. 160–176). New York, NY: Routledge.

Comings, J. P., Parrella, A., & Soricone, L. (1999). Persistence among adult basic education students in pre-GED classes. Retrieved from https://eric.ed.gov/?id=ED437579

Condelli, L. (2006). *A review of the literaute in adult numeracy: Research and conceptual issues* (pp. 1–85). American Institutes for Research.

Courtney, S. (1992). *Why adults learn: Towards a theory of participation in adult education*. London, England; New York, NY: Routledge.

Cross, K. P. (1992). *Adults as learners* (1st ed.). San Francisco, CA: Jossey-Bass.

Davidson, J. C., & Holbrook, W. T. (2014). Predicting persistence for first-time undergraduate adult students at four-year institutions using first-term academic behaviors and outcomes. *The Journal of Continuing Higher Education*, *62*(2), 78–89. https://doi.org/10.1080/07377363.2014.915447

Davis-Kean, P. E. (2005). The influence of parent education and family income on child achievement: The indirect role of parental expectations and the home environment. *Journal of Family Psychology*, *19*, 294–304.

DellaVigna, S. (2009). Psychology and economics: Evidence from the field. *Journal of Economic Literature*, *47*(2), 315–372. https://doi.org/10.1257/jel.47.2.315

Dion, N. (2014). *Emphasizing numeracy as an essential skill* (No. 19, pp. 1–33). Toronto, Canada: Higher Education Quality Council of Ontario.

Dubow, E. F., Boxer, P., & Huesmann, L. R. (2009). Long-term effects of parents' education on children's educational and occupational success: Mediation by family interactions, child aggression, and teenage aspirations. *Merrill-Palmer Quarterly*, *55*(3), 224–249. https://doi.org/10.1353/mpq.0.0030

Estrada-Mejia, C., de Vries, M., & Zeelenberg, M. (2016). Numeracy and wealth. *Journal of Economic Psychology*, *54*, 53–63. https://doi.org/10.1016/j.joep.2016.02.011

Evans, K., Waite, E., & Admasachew, L. (2009). Insight into basic skills form UK longitudinal study. In S. M. Reder & J. M. Bynner (Eds.), *Tracking adult literacy and numeracy skills: Findings from longitudinal research* (1st ed., pp. 242–260). New York, NY: Routledge.

Executive Summary Principles and Standards for School Mathematics. (2000). National Council of Teachers of Mathematics. Retrieved from https://www.nctm.org/uploadedFiles/Standards_and_Positions/PSSM_ExecutiveSummary.pdf

Fitzsimons, G. E. (2005). *What counts as mathematics? Technologies of power in adult and vocational education*. Dordrecht, The Netherlands: Kluwer Academic Publishers. Retrieved from http://accesbib.uqam.ca/cgi-bin/bduqam/transit.pl?&noMan=25127375

Foley, K., Gallipoli, G., & Green, D. A. (2014). Ability, parental valuation of education, and the high school dropout decision. *Journal Journal of Human Resources*, *49*(4), 906–944.

Freire, P. (1970). *Pedagogy of the oppressed*. New York, NY: Herder and Herder.

French, M., & Institute of Medicine (U.S.) (Eds.). (2014). *Health literacy and numeracy: Workshop summary*. Washington, DC: National Academies Press.

Garner, B. K. (2007). *Getting to "got it!": Helping struggling students learn how to learn*. Alexandria, VA: Association for Supervision and Curriculum Development.

Ginsberg, M. B., & Wlodkowski, R. J. (2010). Access and participation. In C. Kasworm, A. R. Rose, & J. Ross-Gordon (Eds.), *Handbook of adult and continuing education*. Thousand Oaks, CA: Sage.

Ginsburg, H. P., & Asmussen, K. A. (1988). Hot mathematics. *New Directions for Child and Adolescent Development*, *1988*(41), 89–111. https://doi.org/10.1002/cd.23219884107

Ginsburg, L., Manly, M., & Schmitt, M. J. (2006). The components of numeracy. *National Center for the Study of Adult Learning and Literacy (NCSALL)*. Retrieved from https://eric.ed.gov/?id=ED495440

Giroux, H. (1983). Theories of reproduction and resistance in the new sociology of education: A critical analysis. *Harvard Educational Review*, *53*(3), 257–293.

Hakstian, A. R., Roed, J. C., & Lind, J. C. (1979). Two-sample T2 procedure and the assumtption of homogenous covariance matrices. *Physchological Bulletin*, *86*, 1255–1263.

Harwell, M., Moreno, M., & Post, T. (2016). A study of the relationship between the ACT college mathematics readiness standard and college mathematics achievement. *Journal of Psychoeducational Assessment*, *34*(3), 269–281. https://doi.org/10.1177/0734282915594069

Hawley, S. T., Zikmund-Fisher, B., Ubel, P., Jancovic, A., Lucas, T., & Fagerlin, A. (2008). The impact of the format of graphical presentation on health-related knowledge and treatment choices. *Patient Education and Counseling*, *73*(3), 448–455. https://doi.org/10.1016/j.pec.2008.07.023

Jasper, J. D., Bhattacharya, C., Levin, I. P., Jones, L., & Bossard, E. (2013). Numeracy as a predictor of adaptive risky decision making: Numeracy and risky decision making. *Journal of Behavioral Decision Making*, *26*(2), 164–173. https://doi.org/10.1002/bdm.1748

Kaput, J., Carraher, D. W., & Blanton, M. L. (Eds.). (2008). *Algebra in the early grades*. Oxford, England: Taylor Francis Group, LLC.

Kasworm, C. E. (2008). Paradoxical understandings regarding adult undergraduate persistence. *The Journal of Continuing Higher Education*, *62*(2), 67–77.

Keller, C., & Siegrist, M. (2009). Effect of risk communication formats on risk perception depending on numeracy. *Medical Decision Making*, *29*(4), 483–490. https://doi.org/10.1177/0272989X09333122

Kilpatrick, J., Swafford, J., Findell, B., & National Research Council (U.S.) (Eds.). (2001). *Adding it up: Helping children learn mathematics*. Washington, DC: National Academy Press.

Knowles, M. (1968). Androgogy, not pedagogy. *Adult Leadership*, *16*(10), 350–352, 386.

Knowles, M. S. (1978). Andragogy: Adult learning theory in perspective. *Community College Review*, *5*(3), 9–20. https://doi.org/10.1177/009155217800500302

Koch, A., Nafziger, J., & Nielsen, H. S. (2015). Behavioral economics of education. *Journal of Economic Behavior & Organization*, *115*, 3–17. https://doi.org/10.1016/j.jebo.2014.09.005

Lewin, K. (1947). Frontiers in group dynamics: Concept, methods, and reality in social science. *Human Relations*, 5–41.

Lusardi, A., Mitchell, O., & Curto, V. (2009). *Financial literacy and financial sophistication among older americans* (No. w15469). Cambridge, MA: National Bureau of Economic Research. Retrieved from http://www.nber.org/papers/w15469.pdf

Maclachlan, K., Tett, L., & Hall, S. (2009). The more you learn the better you feel. In S. M. Reder & J. M. Bynner (Eds.), *Tracking adult literacy and numeracy skills: Findings from longitudinal research* (1st ed., pp. 329–348). New York, NY: Routledge.

Maclean, R., & Wilson, D. (Eds.). (2009). *International handbook of education for the changing world of work*. Dordrecht, The Netherlands. Retrieved from http://link.springer.com/10.1007/978-1-4020-5281-1

Maguire, T., & O'Donoghue, J. (2002). A grounded approach to practitioner training in Ireland: Some findings from a national survey of practitioners in adult basic education. In L. O. Johansen & T. Wedege (Eds.), *Numeracy for empowerment and democracy? Proceedings of the 8th International Conference of Adult Learning Mathematics - A Research Forum (ALM8)* (pp. 120–132). Roskilde, Denmark, Roskilde University, Centre for Research in Learning Mathematics. Hent, UK: Avanti Books. Retrieved from http://www.alm-online.net/images/ALM/proceedings/alm-01-proceedingsalm8.pdf

Ma, J., Pender, M., & Welch, M. (2016). *The benefits of higher education for individuals and society* (pp. 1–43). College Board. Retrieved from https://trends.collegeboard.org/sites/default/files/education-pays-2016-full-report.pdf

Manheimer, R. J. (2002). *Older adult education in the United States: Trends and predictions.* Ashville, NC: North Carolina Center for Creative Retirement.

Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, *50*, 370–396.

McGivney, V. (2004). Understanding persistence in adult learning. *Open Learning*, *19*(1), 33–46. https://doi.org/10.1080/0268051042000177836

Mehrotra, C. M. (2003). In defence of offering education programs to older adults. *Educational Gerontology*, *29*(8), 645–655.

Merkley, R., Thompson, J., & Scerif, G. (2016). Of huge mice and tiny elephants: Exploring the relationship between inhibitory processes and preschool math skills. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/fpsyg.2015.01903

Merriam, S. B. (2001). Andragogy and self-directed learning: Pillars of adult learning theory. In S. B. Merriam (Ed.), *New Directions for Adult and Continuing Education* (Vol. 89, pp. 3–13).

Messick, S. (1994). The interplay of evidence and consequences in the validation of performance assessments. *Educational Researcher*, *23*(1), 13–23.

Metcalf, H., & Meadows, P. (2009). Outcomes of basic life learners. In S. M. Reder & J. M. Bynner (Eds.), *Tracking adult literacy and numeracy skills: Findings from longitudinal research* (1st ed., pp. 225–241). New York, NY: Routledge.

Meyer, B. J. F., Talbot, A. P., & Ranalli, C. (2007). Why older adults make more immediate treatment decisions about cancer than younger adults. *Psychology and Aging*, *22*(3), 505–524. https://doi.org/10.1037/0882-7974.22.3.505

Miller, H. L. (1967). *Participation of adults in education: A force-field analysis.* Boston University, Boston, MA: Center for the Study of Liberal Eduation for Adults.

Ministry of Education. (1959). *15 to 18: A report of the central advisory committee for education (England).* London, England: Department of Education and Science. Retrieved from http://www.educationengland.org.uk/documents/crowther/crowther1959-1.html

National Council For Teaching Mathematics. (2017). Retrieved from https://www.nctm.org/About/

Noss, R. (1998). New numeracies for technological culture. *For the Learning of Mathematics*, *18*(2), 2–12.

Nye, P., & Hillyard, C. (2013). Personal financial behavior: The influence of quantitative literacy and material values. *Numeracy*, *6*(1). https://doi.org/10.5038/1936-4660.6.1.3

OECD. (2013). *PISA 2012 assessment and analytical framework*. Paris, France: OECD Publishing. Retrieved from http://www.oecd-ilibrary.org/education/pisa-2012-assessment-and-analytical-framework_9789264190511-en

OECD. (2016). *Technical report of the survey of adult skills (PIAAC)* (2nd ed.). Retrieved from https://www.oecd.org/skills/piaac/PIAAC_Technical_Report_2nd_Edition_Full_Report.pdf

Ojose, B. (2011). Mathematics literacy: Are we able to put the mathematics we learn into everyday use. *Journal of Mathematics Education*, *4*(1), 89–100.

Oliveira, A. W. (2007). A discussion of rational and psychological decision-making theories and models: The search for a cultural-ethical decision-making model. *Electronic Journal of Business Ethics and Organization Studies*, *12*(2), 12–17.

Orrill, R. (2001). Mathematics, numeracy, and democracy. In L. A. Steen (Ed.), *Mathematics and democracy* (pp. xiii – xix). Woodrow Wilson National Fellowship Foundation. Retrieved from https://www.maa.org/sites/default/files/pdf/QL/MathAndDemocracy.pdf

Pachur, T., & Galesic, M. (2013). Strategy selection in risky choice: The impact of numeracy, affect, and cross-cultural differences: Numeracy, affect, and risky

choice. *Journal of Behavioral Decision Making*, *26*(3), 260–271. https://doi.org/10.1002/bdm.1757

Patterson, M. B., & Paulson, U. G. (2016). Adult transitions to learning in the USA: What do PIAAC survey results tell us? *Journal of Research & Practice for Adult Literacy, Secondary & Basic Education*, *5*(1), 5–27.

Peters, E. (2012). Beyond comprehension: The role of numeracy in judgments and decisions. *Current Directions in Psychological Science*, *21*(1), 31–35. https://doi.org/10.1177/0963721411429960

Peters, E., Västfjäll, D., Slovic, P., Mertz, C. K., Mazzocco, K., & Dickert, S. (2006). Numeracy and decision making. *Psychological Science*, *17*(5), 407–413. https://doi.org/10.1111/j.1467-9280.2006.01720.x

Petrova, D., Garcia-Retamero, R., Catena, A., Cokely, E., Heredia Carrasco, A., Arrebola Moreno, A., & Ramírez Hernández, J. A. (2017). Numeracy predicts risk of pre-hospital decision delay: A retrospective study of acute coronary syndrome survival. *Annals of Behavioral Medicine*, *51*(2), 292–306. https://doi.org/10.1007/s12160-016-9853-1

PIAAC Numeracy Expert Group. (2009). *PIAAC numeracy: A conceptual framework.* (OECD Education Working Papers No. 35). Retrieved from http://www.oecd-ilibrary.org/education/piaac-numeracy-a-conceptual-framework_220337421165

Robinson, K., & Aronica, L. (2015). *Creative schools: The grassroots revolution that's transforming education*. New York, NY: Viking.

Rose, S. (2013). How do teacher preparation programs promote desired dispositions in candidates? *SAGE Open*, *3*(1), 215824401348015. https://doi.org/10.1177/2158244013480150

Rubenson, K. (1977). *Participation in recurrent education: A research review*. Paris, France: Center for Educational Research and Innovation Organization for Economic Cooperation and Development.

Schachter, D., Tharmalingam, S., & Kleinman, I. (2011). Informed consent and stimulant medication: adolescents' and parents' ability to understand information about benefits and risks of stimulant medication for the treatment of attention-deficit/hyperactivity disorder. *Journal of Child and Adolescent Psychopharmacology*, *21*(2), 139–148. https://doi.org/10.1089/cap.2010.0037

Schleicher, A. (2013). *Skilled for life? Key findings from the survey of adult skills*. Brussels, Belgium: OECD.

Schwartz, L. M. (1997). The role of numeracy in understanding the benefit of screening mammography. *Annals of Internal Medicine*, *127*(11), 966. https://doi.org/10.7326/0003-4819-127-11-199712010-00003

Serna, G. R. (2015). Insiders/outsiders: Market signaling and student identity in college choice. *Strategic Enrollment Management Quarterly*, *3*(3), 167–183.

Stewart, S., Lim, D.H., & Kim, J. (2015). Factors influencing college persistence for first-time students. *Journal of Developmental Education*, *38*(3), 12–20.

Sticht, T. G. (2012). Educated parents, educated children: Toward a multiple life cycles education policy. *Education Digest*, *78*(3), 63–67.

Teichert, T., Ferrera, V. P., & Grinband, J. (2014). Humans optimize decision-making by delaying decision onset. *PLOS ONE*, *9*(3), e89638. https://doi.org/10.1371/journal.pone.0089638

Tough, A. M. (1979). *The adult's learning projects: A fresh approach to theory and practice in adult learning* (2d ed.). Austin, TX: Learning Concepts.

Trochim, W. M. K., & Donnelly, J. P. (2008). *Research methods knowledge base* (3rd ed.). Mason, OH: Cengage Learning.

von Winterfeldt, D. (2013). Bridging the gap between science and decision making. *Proceedings of the National Academy of Sciences*, *110*(Supplement_3), 14055–14061. https://doi.org/10.1073/pnas.1213532110

Wagner, T. (2010). *The global achievement gap: Why even our best schools dont́ teach the new survival skills our children need - and what we can do about it*. New York, NY: Basic Books.

Wallace, D. (2011). Parts of the whole : Cognition, schemas, and quantitative reasoning. *Numeracy*, *4*(1). https://doi.org/10.5038/1936-4660.4.1.9

Windisch, H. C. (2016). How to motivate adults with low literacy and numeracy skills to engage and persist in learning: A literature review of policy interventions. *International Review of Education*, *62*(3), 279–297. https://doi.org/10.1007/s11159-016-9553-x

Winne, P., & Hadwin, A. (2008). The weave of motivation and self-regulated learning. In D. Schunk & B. Zimmerman (Eds.), *Motivation and self-regulated learning: Theory, research, and applications* (pp. 297–314). Mahwah, NJ: Lawrence Erlbaum Associates.

Wlodkowski, R. J. (2008). *Enhancing adult motivation to learn: A comprehensive guide for teaching all adults* (3rd ed.). San Francisco, CA: Jossey-Bass, A Wiley Imprint.

Wolla, S. A. (2013). Investing in yourself: An economic approach to education decisions. *Page One Economics*. Retrieved from https://research.stlouisfed.org/publications/page1-econ/2013/02/01/investing-in-yourself-an-economic-approach-to-education-decisions/?&utm_source=fred.stlouisfed.org&utm_medium=Referral&utm_term=related_resources&utm_content=&utm_campaign=pageone

Wong, S. T., Pérez-Stable, E. J., Kim, S. E., Gregorich, S. E., Sawaya, G. F., Walsh, J. M. E., … Kaplan, C. P. (2012). Using visual displays to communicate risk of cancer to women from diverse race/ethnic backgrounds. *Patient Education and Counseling*, *87*(3), 327–335. https://doi.org/10.1016/j.pec.2011.11.014

APPENDIX

Youngstown
STATE UNIVERSITY

One University Plaza, Youngstown, Ohio 44555
Office of Research
330.941.2377
www.ysu.edu

October 17, 2017

Dr. Karen Larwin, Principal Investigator
Ms. Jennifer Hollinger, Co-investigator
Department of Counseling, School Psychology & Educational Leadership
UNIVERSITY

RE: HSRC PROTOCOL NUMBER: 032-2018
TITLE: Numeracy as a Predictor of Learning Commitment

Dear Dr. Larwin and Ms. Hollinger:

The Institutional Review Board has reviewed the abovementioned protocol and determined that it is exempt from full committee review based on a DHHS Category 5 exemption.

Any changes in your research activity should be promptly reported to the Institutional Review Board and may not be initiated without IRB approval except where necessary to eliminate hazard to human subjects. Any unanticipated problems involving risks to subjects should also be promptly reported to the IRB.

The IRB would like to extend its best wishes to you in the conduct of this study.

Sincerely,

Mr. Michael A. Hripko
Associate Vice President for Research
Authorized Institutional Official

MAH:cc

c: Dr. Jake Protivnak, Chair
Department of Counseling, School Psychology & Educational Leadership