Defining and Measuring School Readiness using Confirmatory Factor Analysis Techniques

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Abstract

School readiness skills in kindergarten have been linked with later academic and social achievement. A first step is to identify those skills that are most important for later school success. The current dissertation took a two-study approach to measuring school readiness in kindergarten. Study one proposed a model for measuring school readiness in the fall of kindergarten, comprised of developmental and early academic formative measures. Confirmatory Factor Analysis (CFA) techniques were used to test five nested models proposed to explain school readiness. A two factor cross loading indicators model, comprised of achievement in developmental milestones and early academic skills, best explained school readiness in the fall of kindergarten. Study two examined which of those school readiness skills best predict end of kindergarten early academic achievement. Developmental milestones were measured through composite scores, based upon findings from the first study, as well as early reading and early math measures. Path analysis techniques were used to examine the variance accounted for in springtime early academic skills by fall and winter early academic and development skills. Developmental milestones did not appear to provide additional predictive value for end of kindergarten early academic skills, after accounting for beginning of kindergarten early academic skills. The results of these two studies support a clear definition and efficient measurement approach for school readiness skills in kindergarten. Limitations, future research, and practical implications of these findings are discussed.

Keywords: school readiness, early academics, developmental milestones

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Chapter One

Children who come to kindergarten ready to learn are more likely to be successful throughout their schooling (Davoudzadeh, McTernan, & Grimm, 2015; Duncan et al., 2007; Hecht, Torgesen, Wagner, & Rashotte, 2001; Hooper, Roberts, Sideris, Burchinal, & Zeisel, 2010; National Association for the Education of Young Children (NAEYC), 2002; Reschly, 2010; Snow, 2006). In turn, successful students tend to be more successful adults (Cunningham & Stanovich, 1997; Reynolds, Rolnick, Englund & Temple, 2010). Reynolds et al. (2010) showed the impact that strong early education programs could have on later life success. They found that students who were successful in early education were more likely to graduate high school, attend college, receive higher paying jobs, and were less likely to need remediated education in later schooling, be incarcerated, or make use of financial and social support programs. Ensuring that students start school with the skills that help them to succeed can be seen as a preventative approach to later academic and social emotional difficulties (National Institute of Mental Health, 2002; National Research Council & Institute of Medicine, 2001).

Measuring school readiness across the kindergarten year may provide useful data on how well children are developing the pre-cursor skills to later academic skills and identify possible areas of intervention during that year. Children who receive early academic or behavioral interventions throughout the kindergarten year, have been shown to improve their early academic skills by the end of kindergarten (McClelland, Acock, & Morrison, 2006; O’Connor, 2000; Schneider, Roth, & Ennemoser, 2000).

School Readiness Defined

Early educators and policy makers tend to agree that school readiness is an important goal of early childhood education (National Education Goals Panel (NEGP), 1997; School Readiness Indicators Initiative, 2005). What is less agreed upon is what school readiness looks like and how it should be measured (Daily, Burkhauser, & Halle, 2012; Justice, Bowles, Pence-Turnbull, & Skibbe, 2009; Yoon, 2015). Snow (2006) provided a very broad definition of school readiness as, "the state of child competencies at the time of school entry that are important for later success" (p. 9). She went on to state that the exact components that comprise school readiness are under debate. Graue (2006) echoed this definition by stating that school readiness was a, "set of skills and dispositions that are loosely coupled with success in school" (47). She stated that while the field agrees that school readiness is important, it struggles to provide a clear direction as to what that entails.

Part of the difficulty in defining school readiness may be due to a debate in the field between the importance of academic versus developmental skills in preparing students for school (Graue, 2009; LaParo & Pianta, 2000). Some assessments of school readiness focus exclusively on early reading or early math skills, while others focus on physical or social emotional development (Daily et al., 2012). Early academic assessments tend to be direct measures, while developmental assessments tend to be observational in nature (Bradbury, 2014; Casbergue, 2011). Yet, research has suggested that a whole child approach, meaning both academic and developmental skills included, may be the best fit when assessing school readiness (Daily et al., 2012; Davoudzadeh et al., 2015; Justice et al., 2009; Yoon, 2015). Early childhood curriculum also focuses on preparing the whole child for formal K-12 schooling, by including reading, math, art, physical education, and social emotional development (Graue, 2009).

Using a whole child perspective is further supported by the context in which school readiness resides. When examining the historical, theoretical, and political context, there is a common theme of incorporating all aspects of early child development in the definition for school readiness.

Historical Context

Several historical shifts in the purpose of early childhood education have placed more emphasis on preparing young children for school. First, as more women entered the work force, more young children were entering early childcare settings. As of 2007, it was believed that almost 70% of all 3- and 4-year-olds were in an early childhood setting and that the demand would continue to grow (Pianta, 2007). As more children entered early childcare settings, there was a greater policy push to ensure that these settings were providing children with the educational opportunities needed to thrive in kindergarten (Peisner-Feinberg, 2004; Pianta, 2007).

Second, several large research projects were being conducted that showed the potential positive effects early childhood education could have on closing racial, ethnic, and socioeconomic gaps in achievement (Pianta, 2007). The Abecedarian preschool project and Perry preschool project, as examples, provided children from low socioeconomic neighborhoods early childhood education and those children had better early school outcomes than control peers (Campbell & Ramey, 2010; Schweinhart, 2010).

As a result of these findings, more economic investment was placed on preparing all students for school (Kagan & Kauerz, 2007).

In response to these ideological shifts, the National Education Goals Panel (NEGP) stated as their first goal: all children will start school ready to learn (1997). This goal led to changes in school readiness definitions and policy (Snow, 2006). Prior to this push, school readiness was defined from a maturational perspective. Children entered school when they reached a certain age, typically five years or older, and were believed to have naturally developed the ability to benefit from schooling (Meisels, 1999; Snow, 2006).

Once school readiness became a national education goal, more emphasis was placed upon a skill-based approach (Graue, 2006). Educational policy switched from waiting for children to reach a pre-determined developmental age to providing students with the environment and experiences to prepare them for formal schooling (Meisels, 1999; School Readiness Indicators Initiative, 2005). Emphasis in early childhood education was placed on providing well-rounded experiences to support development across all educational domains (Head Start, 2000). How to measure the attainment of these goals and track developmental progress throughout kindergarten is still under debate though (Meisels, 1999).

Theoretical Context

A number of traditional educational theories have been applied to children's development of school readiness. When school readiness was first conceptualized, Piaget's theory of cognitive development influenced a maturational perspective of school readiness (Piaget, 1936). Children were believed to be school ready when they developed the cognitive ability to benefit from school (Carlton & Winsler, 1999). Piaget's theory is still somewhat influential in school readiness, as most children enter kindergarten around five or six years of age.

Current conceptualizations of school readiness rely on two additional educational theories. Vygotsky's social development theory reinforces the concept that children's skill development relies on the social environment they are in (Vygotsky, 1978). So, providing students with the appropriate environment, matched to their skill level, may help improve a child's early school success. Vygotsky's theory supports the use of formative assessment to identify skill level throughout the kindergarten year.

Bronfenbrenner's ecological systems theory further supports the concept that a child's school readiness is influenced by his or her environmental systems and how those systems interact (Bronfenbrenner, 1979). School readiness measures that assess learning environments in addition to student skills are often based out of this ecological theory. Bronfenbrenner's theory also supports the concept of assessing all aspects of a child's development while measuring school readiness.

In addition, two models have been proposed to explain school readiness development. The first model used a neurobiological approach to school readiness. Blair and Raver (2015) proposed that young children's self-regulatory skills support the development of early academic skills, which support later academic skill development. They argued that as a child's emotionality increases, his or her ability to attend to information decreases, which results in fewer instances of learning. Strong developmental skills lay a foundation for initial academic success (Blair & Raver, 2015). While this model supports a school readiness framework that assesses both academic and developmental skills, the use of intra-child measurements, like gene and physiology, goes beyond the scope of measurement within the school system. A practical model for school settings is still needed in the field.

In a similar way, the second model also proposed that school readiness could be explained by interaction between somewhat academic and social skills. While the neurobiological approach suggested that school readiness be modeled with academic and self-regulatory skills, Cunha and Heckman (2008) divided school readiness skills into cognitive (e.g., academic and intelligence tasks) and non-cognitive (e.g., musical, social) skills. At different stages throughout childhood, the influence of different cognitive and non-cognitive skills on later success shifts as children rely on certain skills more than others. The model did not provide though an exact measure of the influence of each skill, but rather showed that both cognitive and non-cognitive skills influenced student success (Cunha & Heckman, 2008). While each theory is unique, all of the theories suggested that a valid measure of school readiness would include assessing both early academic skills and broader developmental skills.

Policy Context

Policy surrounding school readiness makes defining it difficult. First, policy makers tend to place the most emphasis on early academic skills when trying to predict if students will be successful in formal schooling (Belfield & Garcia, 2014). In contrast, teachers tend to place more emphasis on self-regulatory and behavioral skills, while parents tend to focus on cognitive development and general knowledge (Blair & Raver, 2015; LaParo & Pianta, 2000). There tends to be a difference in what policy makers say about school readiness, what parents expect, and what teachers do within the school setting.

Second, as stated above, current policy conceptualizes school readiness through Bronfenbrenner's ecological theory (Bronfenbrenner, 1979). That is, school readiness is not only a child's readiness to enter school, but also the readiness of the family, school, community, and policy makers to prepare students for school entry (Vernon-Feagans & Blair, 2006). Both the child's readiness for school and the school's readiness for the child are important factors in the student's academic success (Vernon-Feagans & Blair, 2006). This becomes confusing when the term school readiness is used in multiple ways. Most of the time it is used to describe a child's readiness to start school in kindergarten. However, it can also be broadened to include multiple systems' readiness to aid the child when starting school (School Readiness Indicators Initiative, 2005). For the purposes of this paper, school readiness was confined to the readiness of the student, as the study focused on student level data.

Third, defining and assessing school readiness is a state level decision (Snow, 2006). All states and the District of Columbia voluntarily adopted some form of Early Learning Guidelines (ELG), which include standards for multiple areas of development (Daily et al., 2012). Each state created their own ELGs and some states developed assessments to screen for school readiness. The intensity and skills measured in these assessments can vary widely between states, making a consistent definition difficult (Maxwell & Clifford, 2004).

Measuring School Readiness

The nature of early childhood assessment has made assessing school readiness difficult as well. Assessments of young children tend to be developmental in nature and less reliable than other assessments, due to young children's shorter attention spans and more rapid growth (Meisels, 2007; Nelson, 1998). In addition, school readiness assessments tend to measure skills in isolation. Assessments are typically divided into academic and cognitive assessments, measured through direct assessment, versus social, developmental, and behavioral assessments, measured through observation and interviews (LaParo & Pianta, 2000).

The history of school readiness assessment has added to the difficulty in measuring it. School readiness assessments are often conceptualized as gateway assessments to determine if children should enter school, yet caution should be taken when interpreting data from these assessments in this manner (Meisels, 1999). LaParo & Pianta (2000) conducted a meta-analysis of studies that assessed school readiness in preschool and followed participants until kindergarten and/or first grade. They found that academic and cognitive assessments accounted for about 25% of variance in later school achievement. Behavioral and social assessments accounted for an even smaller percentage of the variance at around 10%. These findings show that current school readiness assessments are not sufficiently predictive for use to make high-stakes educational decisions, like delaying the start of school.

Valid school readiness assessment is needed though, with the increased use of data-based decision making within schools and the positive impacts that school readiness can have on later student success. The American Recovery and Reinvestment Act (2009) invested 5 billion dollars in funding for early childhood and emphasized the use of data within classrooms (Daily et al., 2012). Parents, educators and children could benefit from a system to efficiently assess school readiness and measure progress towards that readiness (Snow, 2006). However, a new approach to school readiness is needed. A clear set of skills to measure, including both academic and developmental, coupled with a formative assessment approach could help provide stakeholders with important information about student development across the kindergarten year while not suggesting high-stakes decisions.

Purpose Statement

The purpose of these studies was to identify a set of skills in kindergarten that defines school readiness. Specifically, they were to define a set of skills that provided a comprehensive measure of school readiness in the fall of kindergarten and to investigate how well those skills predict achievement at later points in the kindergarten year. It was expected that three early childhood domains, early reading, early math, and achievement in developmental milestones, together provided the best measure of school readiness.

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Chapter Two

A student's level of readiness when starting school is often linked with successful outcomes later in life (Cunningham & Stanovich, 1997; Hecht, Torgesen, Wagner, & Rashotte, 2001; Hooper, Roberts, Sideris, Burchinal, & Zeisel, 2010; National Association for the Education of Young Children (NAEYC), 2002; Reschly, 2010; Reynolds, Rolnick, Englund & Temple, 2010; Snow, 2006). School readiness is a broad term, though, without clear distinctions about how it should be assessed in the schools (Graue, 2006; Snow, 2006; Vernon-Feagans & Blair, 2006). Young children need to develop a wide set of skills in order to be successful in school (Davoudzadeh, McTernan, & Grimm, 2015; Justice, Bowles, Pence-Turnbull, & Skibbe, 2009). Yet, school readiness assessments do not always include a full range of developmental skills (Daily, Burkhauser, & Halle, 2012; Yoon, 2015).

School Readiness Domains

Three domains are relevant to school readiness: Early Reading, Early Math, and Developmental Milestones. Background on each of these areas is provided as well as research to support the inclusion of the skill in school readiness assessments. In addition, examples of some common assessments in each area are provided.

Importance of Early Academic Skills. Early reading and early math skills have been shown to be the best predictors of later academic success, beyond other cognitive, behavioral, and environmental factors and across different populations of students (Cunningham & Stanovich, 1997; Duncan et al., 2007; Hecht et al., 2001; Hooper et al., 2010). Low early academic skills were also shown to be the best predictor of later grade retention in elementary school (Davoudzadeh et al., 2015). Inclusion of early academic skills in the assessment of school readiness may provide information to help determine a student's readiness for school.

Early Reading. Early reading can best be thought of as the beginning stage of learning to read. Often referred to as emergent or precursor reading, early reading is defined as skills, knowledge, and attitudes that precede conventional reading and writing, as well as, the environments that support the development of early reading (Whitehurst & Lonigan, 1998). One model of early reading development, proposed by Whitehurst and Lonigan (1998), divided early reading skills into two independent processes: outside-in and inside-out. Outside-in processes were skills that help the student understand the context of the reading environment, and can also be conceptualized as meaning related skills. Inside-out skills were described as rules for translating print into sound, or sound into print, and can be thought of as code related skills.

Early reading skills. Skills that are most predictive of later success in conventional reading and writing are believed to be the most important when developing early reading competence (Lonigan & Shanahan, 2008). Four areas of early reading are defined due to their importance for later reading development and, thus, their importance to early reading assessment (Lonigan & Shanahan, 2008). Alphabet knowledge is knowledge of both the names of printed letters and the ability to associate sounds with those letters (Snow, Burns, & Griffin, 1998). Phonological awareness is a student's ability to discriminate the sounds that comprise language (Lonigan & Shanahan, 2008). Within phonological awareness, a sub-skill called phonemic awareness is the ability to detect, manipulate, or analyze the smallest unit of sounds in a language (Snow et al., 1998). According to the National Reading Panel (2000), strong phonemic awareness is the first of five developmental steps to becoming a successful reader.

Concepts of print can be thought of as the conventions of reading. Understanding concepts of print includes knowing that words are read from left to right, how to hold a book, and where to begin reading (Snow et al., 1998). Finally, oral language skills, including both spoken vocabulary and grammar, are also predictive of other early reading and later reading skills (Dickinson & McCabe, 2001).

Early Reading Measures. Both formative and summative assessments are available to measure early reading skills. Summative assessments, like the Test of Preschool Early Literacy (TOPEL; Lonigan, Wagner, Torgesen, & Rashotte, 2007), are used to assess attainment of early reading skills and help to identify students who may be at risk for future reading difficulties. The TOPEL assesses three broad early reading skills, print knowledge, vocabulary, and phonological awareness, and correlations with first grade reading skills ranged from r = .30 - .60 (Wilson & Lonigan, 2009). However, as a summative measure, it does not monitor the progress of students as they develop early reading skills.

Three formative early reading assessments are available. The Individual Growth and Development Indicators of Early Literacy (IGDIs-EL; McConnell, Wackerle-Hollman, Bradfield, & Rodriguez, 2012) are screeners available at three benchmark times throughout the school year. Five assessments cover skills in oral language, letter-sound correspondence, and phonemic awareness. Concurrent validity with the TOPEL ranged from $r = .45 - .76$ (McConnell et al., 2012). The Revised Get Ready to Read! (GRTR-R; Whitehurst & Lonigan, 2001) is similar to the IGDIs-EL, in that it is a screening tool to assess school readiness during the transition to kindergarten. Along with alphabet knowledge and phonemic awareness, the GRTR-R also contains a measure of emergent writing. Concurrent validity with the TOPEL was tested at two times with correlations of $r = .71$ and .72 (Wilson & Lonigan, 2009).

The Dynamic Indicators of Basic Early Literacy Skills (DIBELS; Good & Kaminski, 2002) have progress monitoring measures in addition to screeners. DIBELS are comprised of seven measures that assess early reading skills like phonemic awareness, vocabulary, and alphabet knowledge, and can be used with students from kindergarten through 6th grade. While DIBELS includes early reading measures, its focus extends into early reading development as well. Riedel (2007) reported that DIBELS measurement system correctly classified between 56% and 68% of students at-risk for reading development, depending on the measure. It should be noted that only those measures related to early reading skills were included for the purposes of this paper.

None of the above assessments are intended to track school readiness as a whole construct though. They are each independent assessments, focused on early reading, and do not easily fit into a broader school readiness theory or assessment framework.

Early Math. Similar to the relationship between early reading and reading, early math can be conceptualized as the foundational skills that aid in the development of more advanced mathematical skills. The main focus of early math is on the development of number sense (Baroody, 2004; Clements, 2004; Clements & Sarama, 2007; Cross, Woods, & Schweingruber, 2009; NAEYC, 2002). Number sense is comprised of three distinct factors: facility with counting, understanding relations, and simple arithmetic operations (Cross et al., 2009; Purpura & Lonigan, 2013).

Early Math Skills. Counting is fundamental to number sense and can be a more complicated cognitive process than one may initially suspect. Gelman and Gallistel (1978) outlined five principles of counting, which are often assessed with early math measures: one-to-one correspondence, stable order, cardinality, abstraction, and order irrelevance. Generally measured with counting, subitizing is the ability to name small quantities, usually of no more than three, without having to count them (Sarama & Clements, 2009).

Relations incorporate how numbers relate to one another on the number line as well as how verbal and nonverbal number skills are interrelated (Cross et al., 2009; Purpura & Lonigan, 2013). Assessing student's understanding of number relations includes identifying numbers on the number line, identifying numbers that are bigger and smaller, and matching written and Arabic numerals with item sets (Purpura & Lonigan, 2015).

Arithmetic operations includes beginning addition and subtraction and the concepts of composition and decomposition (Cross et al., 2009; Purpura & Lonigan, 2013). Composition, and its counterpart, decomposition, are the concepts that mathematical entities can be comprised of smaller units and built upon each other to create a new mathematical concept (Cross et al., 2009). These concepts can lay the groundwork for more advanced mathematics in later years (Cross et al., 2009).

Early Math Measures. Many of the early reading measures discussed previously have early math counterparts. On the summative assessment side, the Test of Early Mathematics Ability, third edition (TEMA-3; Ginsburg & Baroody, 2003) is an individually administered assessment measuring the attainment of early math skills, focusing on the domain of number sense. Internal consistency was reported to be above $\alpha = .92$ and concurrent validity with other norm-referenced assessments ranged from r =. 55 -. 91 (Ginsburg & Baroody, 2003). Ryoo et al. (2015) found, however, that the factor structure proposed by the TEMA-3 may not be an accurate reflection of the intended construct being measured.

The Individual Growth and Development Indicators of Early Numeracy (IGDIs-EN; Hojnoski & Floyd, 2013) are comprised of measures to assess counting, number identification, and quantity comparison in preschoolers. Like the IGDIs-EL, for early reading, the IGDIs-EN can be used as both screeners and progress monitoring tools. Concurrent validity with standardized math assessments for early math ranged from r = .60 -.75 (Hojnoski & Floyd, 2013). While the IGDIs system has measures for both early reading and early math, it does not include assessments for developmental domains.

The Preschool Early Numeracy Scales (PENS; Purpura & Lonigan, 2015) are similar to the IGDIs-EN in that they serve as a progress-monitoring tool for early math skills, but unlike the IGDIs-EN, measure a wider variety of skills, with twelve assessment tasks within the three number sense domains. Concurrent validity with the Woodcock-Johnson, Third Edition Applied Problems subtest (WJ III-AP; Woodcock, McGrew, & Mather, 2007) ranged from r = .38 - .70 (Purpura & Lonigan, 2015).

The Early Numeracy Skill Indicators (ENSI; Methe, Hintz, & Floyd, 2008) are another form of progress monitoring for early math skills. The ENSI provide measures of oral counting, numeral identification, and ordinality. Concurrent validity between the ENSI and the TEMA-3 ranged from $r = .39 - .89$ (Methe et al., 2008). Similar to the early reading assessments, none of these early math assessments fit into a broader school readiness framework though.

While assessing these early academic skills independently can provide valuable information about a student, these measures alone do not provide a complete picture for school readiness. Assessing early reading and early math skills, in addition to developmental milestones, will likely provide a more accurate representation of a student's school readiness (Daily et al., 2012; Davoudzadeh et al., 2015; Justice et al., 2009; Yoon, 2015). A system that includes both developmental domains and academic formative assessments may increase the efficiency and validity of school readiness assessments.

Developmental Milestones. One of the significant differences between early childhood education and K-12 education is the developmental focus of early childhood (Graue, 2006). Early childhood education has increasingly been seen as a context for students to develop skills important for K-12 schooling (Pianta, 2007). Included in the goals of early childhood education is to support the development of the child in all aspects of his or her life. The National Education Goals Panel (NEGP; 1997) outlined five broad areas of school readiness that cover the wide range of development that young children experience. These five domains have been recognized across early education policy and programs and are presented below (Head Start, 2000; NAEYC, 2009; NEGP,1997; School Readiness Indicators Initiative, 2005).

Social and Emotional Development. Social development, in the context of school readiness, includes the ability to interact with peers and adults, but also trust in caregivers, self-advocacy, and empathy development (NEGP, 1997; School Readiness Indicators Initiative, 2005). A child is thought to be socially ready for school, when he or she can independently function with others; getting one's needs met while respecting the needs of others. The ability to share, take turns, and recognize one's own preferences in activities help to maintain an appropriate classroom climate necessary for learning (Head Start, 2000).

Similarly, a child has developed the emotional competence to be successful in school when he or she can begin to recognize feelings both within themselves and others and regulate their emotions appropriately (School Readiness Indicators Initiative, 2005). Emotional development has often been where children experienced the most difficulty in transitioning to school (Rimm-Kaufman, Pianta, & Cox, 2000).

Often measured together, social and emotional development can have a profound effect on a student's future school success. Societal risk factors that can affect a child's social emotional development have been linked with lower school achievement (Huffman et al., 2000). In contrast, students exposed to social emotional curriculum in preschool have been shown to be more emotionally intelligent into elementary school (Moore et al., 2015). In fact, social emotional learning in early childhood was shown to predict teacher report of academic achievement and classroom adjustment in kindergarten (Denham, Bassett, Zinsser, & Wyatt, 2014). Classroom climate is often cited as an influencing factor on student's social emotional development (Hamre & Pianta, 2007). Torres, Domitrovich, and Bierman (2015) suggested that strong interpersonal relationships between teachers and students provided a positive context to develop social emotional skills, which promoted readiness for school among participants.

Approaches to Learning. Children's attitudes, learning habits, and ways of approaching difficult situations have impacted their success within school (Denham et al., 2012). Encouraging a child's persistence, curiosity, and enthusiasm toward learning has helped students across multiple domains of development (School Readiness Indicators Initiative, 2005). Children that have a more positive attitude about starting school have been shown to have more success through the transition to school (Daniels, 2014). Children's eagerness to participate in tasks and learn independence was also linked to 5th grade achievement (Claessens, Duncan, & Engel, 2009). Even parents' attitudes toward school have affected student's school readiness. Parents with poorer attitudes toward school tended to have children at higher risk for school difficulties (Okado, Bierman, &Welsh, 2014).

Health and Physical Development. A child's global health, motor development, and body regulation are included in this domain (School Readiness Indicators Initiative, 2005). Healthy students tend to be those that are more successful in school. Poor nutrition and exposure to environmental risk factors has been linked to poor school readiness outcomes (Pascoe, Shaikh, Forbis, & Etzel, 2007). Students who had neonatal risks, poor general health, or hospitalizations also tended to have lower learning and pro-social skills

(Kull & Levine-Coley, 2015). Motor development, including the ability to move around independently, and hand-eye coordination, for self-care skills, help students achieve independence in school (Head Start, 2000). Likewise, the ability to focus one's attention to pertinent tasks, be alert and energetic, and regulate one's body also helps students to be ready for school (Denham, Warren-Khot, Bassett, Wyatt, & Perna, 2012).

Cognitive Development. Cognitive development can be a broad term, but in the context of school readiness, it is often separated into three categories. The first category includes age-appropriate general knowledge about the world and basic common sense concepts, which can help establish a foundation for future academic learning (School Readiness Indicators Initiative, 2005). These cognitive skills can increase school readiness above and beyond early academic knowledge. When a measure of general knowledge was added to early reading and early math assessments, the inclusion of general knowledge with other early academic indicators better predicted later academic success across reading, mathematics, and science (Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010).

The second category, called problem solving skills, including reasoning, asking questions, abstract thought, and imagination, are skills that can be applied across the school curriculum (Head Start, 2000; NEGP, 1997; School Readiness Indicators Initiative, 2005). These skills are just beginning to develop in the preschool years, but research has shown that they can be fostered within classroom settings. Nevanen, Juvonen, & Ruismaki (2014) found that children who engaged in an imaginative project in early childhood had better problem-solving skills in later schooling.

The third category encompasses executive functioning skills, including working memory, inhibitory control, and flexibility (Carlson, Zelazo, & Faja, 2013). Executive functioning's application to school readiness has been cited as an area of scientific growth and many studies have examined the influences of these skills across several levels of psychobiology (Blair et al., 2007; Gottlieb, 1991). A broad examination of all of these studies is beyond the scope of this paper due to the limitations in schools for addressing individual development beyond the behavioral level.

At the behavioral level, attentiveness, task persistence, flexibility, and organization have all been linked to 5th grade achievement (Claessens et al., 2009). These skills have also been shown to account for unique variance in school readiness above and beyond the variance accounted for by early academic skills, specifically early reading and math skills (Fitzpatrick, McKinnon, Blair, & Willoughby, 2014).

Language Development. Language development in the context of school readiness includes both the ability to communicate in order to learn from instruction, but also classroom communication with teachers and peers. School communication is often measured with expressive and receptive language assessments, which encompass a student's knowledge of school vocabulary (School Readiness Indicators Initiative, 2005). Pragmatic language is also important for success in school for communicating socially with peers, expressing needs, and understanding non-verbal communication (NEGP, 1997).

Oral language skills have been conceptualized in a developmental framework beginning with the ability to discriminate sounds and ending with full discourse of abstract ideas, which underlies later academic skills, like reading and mathematics (Dickinson, Anastasopoulos, McCabe, Peisner-Feinberg, & Poe, 2003). As such, language development and language modeling has been linked with later academic success (Briscoe, Bishop, & Frazier-Norbury, 2001; Dehaehne, 1992; Hamre & Pianta, 2007; Lee, 2011; Preston et al., 2010; Sarnecka, Kamenskaya, Yamana, Ogura, and Yudovina, 2007). Similarly, concurrent language difficulties have been shown to have a negative impact on school readiness (Justice et al., 2009).

Developmental Milestone Assessments. These early childhood domains are often assessed together using standardized norm-referenced assessments or screeners (LaParo & Pianta, 2000). They frequently include a mix of direct skill assessment, observations in play environments, and interviews with the parents (Kagan & Kauerz, 2007). A number of assessments have been developed to assess children's development in major life domains. Most readily used assessments for measuring school assessment are intended to identify students who are at-risk for later school failure. Therefore, these assessments are often validated based upon their predictive validity and not on how well the test reflects a theoretical representation of school readiness (Janus & Offord, 2007). Some frequently used assessments are discussed below.

The Bracken School Readiness Assessment, Third Edition (BSRA-3) is a screener used to assess student's understanding of basic cognitive concepts in preschool, like colors and shapes (Bracken, 2007). Using teacher concern, retention, and special education referrals as the dependent variable, the Bracken identified 62% of students who went on to have difficulty in school readiness (Panter & Bracken, 2009).

The Developmental Indicators for the Assessment for Learning, Fourth Edition (DIAL-4) is a screener for early childhood, which assesses all five developmental domains (Mardell & Goldenberg, 2011). The authors of the DIAL-4 state that its purpose is to identify students at-risk for potential difficulties in later ages and it is not presented as a school readiness measure. An independent study of the DIAL-4's predictive validity has not been conducted. The DIAL-4 covers some early math and early reading content, but does not cover the breadth of areas that an early reading or math screener contains.

The Brigance Inventory of Early Development, Third Edition (Brigance IED III) also covers the five developmental domains and includes both a screener and progress monitoring options (Brigance & French, 2013). Correlations between the Brigance IED III and other established developmental scales ranged between r = .27 - .67 (French, 2013).

The Ages and Stages Questionnaire, Third Edition (ASQ3) is a parent report of their child's development in the five developmental domains (Squires & Bricker, 2009). The ASQ3 is used widely as a screener in clinical settings. However, it is only appropriate for children from birth to 5 years 6 months, so it cannot be used to track school readiness skills through kindergarten. In addition, it does not include comprehensive measures of early reading or early math. Using the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III; Bayley, 2005) as a reference measure, the ASQ correctly classified 41% of a sample of young children (Veldhuizen, Clinton, Rodriguez, Wade, & Cairney, 2015).

Some assessment systems measure different aspects of school readiness, yet no assessment system measures both developmental domains and academic skills together. The utility of a school readiness model that includes developmental domains, early reading, and early math still needs to be examined.

Next Generation Assessments System

Assessments that are performed on-line and use technology enhanced or interactive items are often referred to as next generation assessments. These assessments can be beneficial to schools when they increase efficiency and provide more timely feedback than traditional paper and pencil assessments (Thelwall, 2000). More efficient assessment administration may help improve early childhood assessment results, as young children have shorter attention spans (Nelson, 1998). Developing a next generation school readiness assessment may help to increase the efficiency with which young students are assessed.

The Formative Assessment System for Teachers (FAST; Christ et al., 2015) is a type of next generation assessment system. FAST has developed measures for early reading, early math, and developmental milestones. The availability of all three domains coupled with a next generation measurement approach provides a potentially useful way to measure school readiness. Therefore, FAST measures were used in this study and technical information is provided in the methods section.

Purpose Statement

The purpose of this study was to examine what early childhood skills are important for assessing school readiness. Specifically, it was to define the factor structure of school readiness and to examine a possible method for assessing those skills. It was expected that proficiency in early reading, early math, and developmental milestones together best explain readiness for kindergarten.

Methods

Participants

A total of 266 kindergartners were rated on DevMilestones, 255 kindergartners were administered the earlyReading assessment, and 254 kindergartners were administered the earlyMath assessment. In total, 253 kindergartners had scores in earlyReading, earlyMath, and DevMilestones, and this sample was used for the study. Listwise deletion was used for participants that were missing data on a variable. Estimation methods were considered for missing data but only about 4% of the sample was deleted with listwise deletion; sample size after deletions was adequate for the analysis. Listwise deletion can be an adequate method for handling missing data when the percentage of missing data does not affect statistical power (Kim & Curry, 1977; Tabachnick & Fidell, 2013).

All participants in the study were enrolled in public schools in the state of Minnesota and all assessments were conducted in English. A large percentage of participants' ethnicities (n = 129; 51%) and special education status (n = 76; 30%) were not reported; this is further discussed in the limitations section. The sample was comprised of participants who identified as American Indian/Alaska Native (n = 97; 38%) and White (n = 27; 11%). The majority of participants were five years old (n = 196; 78%); the remainder of participants were six years old (n = 57, 22%). Approximately half of the participants were male (n = 137; 54%). The majority of participants were also general education students (n = 154; 61%). The remainder of participants qualified for special education under the disability categories of Speech-Language Impairment (n = 12; 5%), Developmental Delay (n = 8; 3%), Multiple Disabilities (n = 2; 1%), and Autism (n = 1; <1%).

Measures

Participants were administered FAST earlyReading, earlyMath, and DevMilestones to measure the three school readiness domains hypothesized in the study (Christ et al., 2015). All three measures can be used in the fall of kindergarten to screen incoming students. The three measures are discussed below and psychometric statistics for earlyReading and earlyMath are presented in Table 1 and DevMilestones in Table 2.

earlyReading. The FAST earlyReading assessment for the fall of kindergarten was designed to cover four domains of early reading development: concepts of print, phonemic awareness, phonics, and decoding. The earlyReading composite score was selected as an estimate of early reading skills in the model as it provided an efficient and reliable measure of early reading achievement (see Table 1). The composite score was comprised of four subtests, which are presented below with a short description of each subtest to showcase the construct that was estimated in the model.

Composite scores were constructed using weightings, based upon previous factor analysis studies (Christ et al., 2015). The value of the factor scores used to create the composite were not widely available, but the magnitude of the weighting was as follows: high weighting of concepts of print, moderate weighting of onset sounds, and low weightings of letter names and letter sounds. Composite scores at or below 34, representative of the 40^{th} percentile, indicate some risk for future reading difficulty and scores at or below 29, representative of the 20^{th} percentile, indicate high risk.

Concepts of Print. The concepts of print subtest included twelve items that assessed if the participant understood the conventions of reading. Included in this subtest was knowing how to hold a book, understanding that printed text holds meaning, reading from left to right, and understanding punctuation. The subtest was not timed but typically takes one to two minutes to complete. A timer is included in the on-line platform in order to assess fluency. Scores can be reported as percent accuracy, items correct per minute, and total items correct. Scores of total items correct were included in the composite and possible scores ranged from 0-12.

Onset Sounds. During this subtest, participants were shown a set of four pictures and asked to select the picture whose name began with the same sound the administrator was saying. This subtest was also not timed and typically takes two minutes to complete. Again, a timer is included in the on-line platform in order to assess fluency. Scores can be reported as percent accuracy, items correct per minute, and total items correct. Total items correct scores were included in the composite and possible score range was from 0-16.

Letter Names. Participants were asked to name upper and lower case letters in isolation. They were given one minute to name as many letters, out of 100, as they could. Scores can be reported as percent accuracy, items correct per minute, and total items correct. Total items correct scores were included in the composite score.

Letter Sounds. Similar to letter names, participants were asked to say the sound associated with upper and lower case letters, which were presented in isolation. They were given one minute to name as many letter sounds as they could. Scores can be reported as percent accuracy, items correct per minute, and total items correct. Total items correct scores were included in the composite score. The student was provided 80 letter sounds that could only be pronounced in one way (i.e., /B/, /k/). If the student completed all 80 sounds before the one minute, they were also presented with 28 dual letter sounds (i.e., /Ē/, /ă/) to name within the minute.

earlyMath. The FAST earlyMath assessment is intended to measure three broad domains of early math: Number, Relations, and Operations. Three earlyMath subtests comprised the earlyMath composite score, which was used in the model to estimate an efficient and reliable measure of early math skills (see Table 1). Composite scores were again constructed based upon weightings from previous factor analysis studies (Christ et al., 2015). Number sequence was weighted highly in the composite score, match quantity was weighted moderately, and numeral identification was lowly weighted. A composite score at or below 34 indicated some risk of later math difficulty and a score of 27 or below indicated high risk for later difficulties. The three subtests are presented below.

Number Sequence. The number sequence subtest was a measure of participant's understanding of the mental number line. Participants responded to four types of questions within this subtest. Count sequence items instructed the participant to verbally count forwards or backwards, given three consecutive numbers by the examiner. Number after items, number before items, and number between items included questions related to assessing how numbers relate to one another on the number line. The subtest was an open-ended, untimed measure, which usually takes 1-2 minutes. Scores for this subtest can be reported as items correct and percent accurate. Items correct was used in the composite score and possible scores ranged from 0-13.

Match Quantity. Participants were asked to match an array of dots with one of four numerals presented. Dot arrays were both configured and random, and participants were given one minute to complete as many items as they could. Scores can be reported as percent accurate, items correct per minute, and total items correct. Possible scores ranged from 0-20.

Numeral Identification. Participants were instructed to name as many numerals as they could within one minute. All numerals between 0 and 31 were used and numerals were presented in a non-sequential order. Scores can be reported as percent accurate and items correct per minute. Students are provided 110 numerals to identify within the one minute.

Developmental Milestones. Students' acquisition of developmental milestones was measured by the FAST DevMilestones assessment. DevMilestones is a criterion-referenced rating scale of student's development across six school readiness domains. The student's teacher rated participants' performances in each domain based upon informal observations of the student. Forty-three items in all were rated, divided among the six domains, which are available in Appendix A.

Ratings were on a five point scale where teachers selected one of the following: Not yet at first level (0), Inquiring (1), Emerging (2), Incorporating (3), Mastering (4).

Each item was rated from 0-4 and the scores were averaged across the total number of items to derive the student's score for that domain; therefore, scores ranged from 0-4. Support for use of creating composite scores off of item ratings was based upon a previous confirmatory factor analysis, χ^2 (751) = 2283.394, p< .01, CFI = .92, RMSEA = .09. These results suggested an adequate fit and that DevMilestones is comprised of six factors, with items for each domain loading onto its respective factor.

All six domains available on the assessment were specified in the model and each domain is described below. Available reliability statistics are presented in Table 2. DevMilestones was not available for commercial use at the time of this study, so reliability and validity statistics were still pending.

Social and Emotional Development. Seven items were rated to assess each participant's Social and Emotional Development. The items in this domain rated each participant's understanding and maintaining of reciprocal relationships, emotional awareness and regulation, and self-confidence and independent engagement.

Approaches to Learning. The Approaches to Learning domain was made up of six items. The assessment measured the student's curiosity, risk taking, imagination, and persistence with tasks. It also contained items that examine the student's adaptability to change and the way the student learns from previous experiences.

Physical and Motor Development. Six items assessed the student's Physical and Motor Development. The items in this domain focused on gross and fine motor development as well as the student's understanding and engagement in healthy lifestyle habits.

Creativity and the Arts. Four items comprised the Creativity and the Arts domain. Creativity, through this assessment, was measured by examining the student's use of media, skills, and resources to independently complete artistic tasks. It also examined the student's interest in and opinions about artwork.

Cognitive Development. Ten items comprised the Cognitive Development domain. Items on this measure included early geometry and number concepts, problem solving skills and environment exploration, and basic general knowledge about the community. The measure also assessed the child's memory and scientific approach to tasks.

Language, Literacy, and Communication. Ten items also comprised the Language, Literacy, and Communication domain; from here on out referred to as Language Development. The items involved conventional and pragmatic language, social communication, and some early reading skills. The domain also included items that examine interest and motivation for engaging in conversation and reading.

Procedures

Data were collected in the fall for each participant by his or her school, while attending public kindergarten classrooms. Each student's data were collected and uploaded by the school, using the FAST Bridge to Learning on-line platform. Teachers were trained on both the assessments and on-line platform through the FAST training procedures available on-line. These data were collected after request from the Minnesota Department of Education (MDE) for public kindergarten classrooms to collect student level achievement in early reading, early math, and developmental milestones. The earlyReading and earlyMath measures were collected through one-on-one skill based assessment, using both on-line and paper and pencil tasks. All scoring was completed on-line. The DevMilestones data were collected through teacher observations, rated following a six-week period of initial observations at the beginning of the year. All ratings were completed for each student using the on-line DevMilestones platform. Data were obtained through request from the FAST Bridge to Learning system and available demographic information, composite scores, and domain scores for each measure were supplied.

Analysis. A confirmatory factor analysis (CFA) was performed through IBM SPSS AMOS 23 on the eight FAST measures presented above. The CFA was conducted following Rindskopf and Rose's (1998) method of comparing nested models. Models were tested by comparing the fit of competing models, from the least to the most restrictive model. Maximum likelihood was used to estimate the model parameters. Bollen-Stine bootstrap was used due to the possible violation of independence from teacher ratings. The Bollen-Stine method was selected because it has been shown to better correct for possible data violations than Satorra-Bentler scaling or maximum likelihood with robust indicators in small sample sizes (Nevitt & Hancock, 2001; Yuan & Bentler, 2000).

Proposed Models. Four models (i.e., models 1, 3-5) were tested based upon models used by Sawaki, Stricker, and Oranje (2009). A fifth model was tested (i.e., model 2) because of the potential theoretical value of allowing language and cognitive development to load onto an Early Academic factor. The hypothesized path diagrams are presented in Figure 1 in order of their restrictiveness, where circles represent latent variables and rectangles represent measured variables. Absence of a line connecting variables implies no hypothesized direct effect.

1) Bi-Factor Model (Upper Left of Figure 1): This model hypothesized the presence of a general school readiness factor, which all of the measures load on, as well as two other factors, Early Academics and Development.
2) Two Factor Cross Loading Indicators Model (Upper Middle): This model hypothesized two factors, Early Academics and Development. All six developmental milestone measures load on the Development factor. Early reading and early math load on the Early Academic factor, with cognitive and language development, which cross load onto Development.
3) Correlated Two Factor Model (Upper Right): This model hypothesized two factors, Early Academics (i.e., early reading and math), and Development (i.e., developmental milestones), which are distinct but correlated.
4) Single Factor Model (Lower Left): This model hypothesized that all eight measures load on a single factor, explained as School Readiness.
5) Higher-Order Factor Model (Lower Right): This model specified a higher-order factor of School Readiness, represented by two observed variables of early reading and math, and one latent variable of Development.

The first model was selected as the baseline model as it was the least restrictive both theoretically and statistically. The remaining models were then compared with the baseline model to determine the model that best fit. Model fit was assessed by examining

χ^2 probability and difference tests. With CFA techniques, a non-significant χ^2 suggests that the hypothesized model does not differ from the population model. In other words, that the model fits the population of students. Chi-squared difference tests were used to determine if a nested model is a significant improvement over the baseline model. In the case of χ^2 difference tests, a significant finding suggests an improved model fit. Model fit was also assessed with the following goodness-of-fit criteria:

1) Comparative Fit Index (CFI): A ratio of the fit of the estimated model over the null hypothesis model. CFI values greater than .90 indicate an adequate fit and values above .95 indicate a good fit (Hu & Bentler, 1999; Tabachnick & Fidell, 2013).
2) Root Mean Square Error of Approximation (RMSEA): A calculation of the lack of a good fit compared to the saturated (or ideal) model. RMSEA values equal to or below .08 indicate an adequate fit and values equal to or below .06 indicate a good fit (Browne & Cudeck, 1993, Hu & Bentler, 1999).
3) Expected Cross Validation Index (ECVI): A measure of the extent to which a model can be replicated with a different sample. No clear cut-offs are established but the lower the value the better the replication possibilities when comparing across models (Sawaki et al., 2009).

Models that resulted in significant improvement over the baseline model were compared and the final model was determined by the best overall fit indices. Results are presented below with additional post hoc model modifications.

Results

The analyses were conducted in four phases. First, descriptive statistics for the eight observed variables were calculated. Second, the models were compared against the baseline model to determine the best model fit. Third, post hoc model modifications were performed for the best fitting model to establish a final model. Fourth, parameter estimates were examined on the final model to determine significant factor loadings. Data were examined and analytic assumptions were checked prior to analysis.

Analytic Assumptions

Assumptions were analyzed to ensure that the data was appropriate for the selected analysis. Appropriate sample size can vary widely in factor analysis literature. Methodological researchers offer both absolute number suggestions and sample size to variable ratio suggestions. When basing the sample size off of absolute numbers, MacCallum, Widaman, Preacher, and Hong (2001) suggested that 100 subjects be used in a factor analysis. Hatcher (1994) stated that the larger of 100 subjects or five times the number of variables be used as the sample size. If sample size ratios are used, Hair, Anderson, Tatham, and Black (1995) suggested that a 20:1 ratio of participants to variables be used. Costello and Osborne (2005) also noted that 78.6% of published factor analysis studies have used the 20:1 ratio or less. Eight observed variables were used in this study. Thus, 100 subjects was the suggested absolute number of participants and 160 was the suggested number of participants for a ratio to sample size approach.

For the current study, 253 participants had data for all eight observed variables; one participant was missing developmental milestones data and 11 participants were missing both early reading and early math data. Because this sample size was adequate for the number of variables, this analysis used only complete cases. There was no evidence of a non-ignorable missing data pattern. The ratio of cases to observed variables was 32:1 and the ratio of estimated parameters, at the most, was 16:1.

Normality of variables was assessed by visually examining histograms using IBM SPSS and by calculating standardized skewness and kurtosis, reported in Table 3. All eight observed variables were normally distributed and no variable had a standardized skewness or kurtosis greater than 3.75. It should also be noted that the impact of non-normality on CFA techniques diminishes with sample sizes greater than 200 (Waternaux, 1976). Linearity was assessed using IBM SPSS scatterplots and best-fit lines for all observed variable combinations. All observed variables appear to be linearly related, if at all.

No univariate or multivariate outliers were detected in the dataset. For univariate outliers, only one participant had a z-score greater than 3.3. Because of the large sample size, a small number of large z-scores can be expected (Tabachnick & Fidell, 2013). Upon examination of boxplots, this participant did not appear to be an outlier. Multivariate outliers were assessed using Mahalanobis distances and no distances were significant outliers ($\chi^2_8 = 26.125$). Visual examination of scatterplots and multivariate plotting supported this statistic.

Descriptive Analyses

Table 3 provides descriptive statistics for the eight measured variables used in the CFA. Results suggested that the sample used in this study had average mean scores, as the mean of the earlyReading assessment was at the 65th percentile and the mean of the earlyMath assessment was at the 55th percentile of the assessment norming population. The DevMilestones means and standard deviations suggested that the average student in this sample was classified as "emerging" in the fall of kindergarten, which constituted an average sample. Percentiles for composite scores on the DevMilestones measure were not available at the time the study was conducted, but kindergarten students in the fall are expected to be at the "emerging" level (Christ et al., 2015). Table 4 presents the Pearson's correlation matrix for the eight measures in the model. All of the measures were significantly correlated ($p < .01$). The earlyMath and earlyReading measures were strongly correlated ($r = .76$), and they were both weakly to moderately correlated with the DevMilestones measures ($r = .27$ - $.64$). The DevMilestones measures were strongly correlated with each other ($r = .68$ - $.86$).

Model Comparison

The bi-factor model (model one) was first run to establish a baseline model and fit-indices suggested a poor fit, χ^2 (15, $N = 253$) = 154.25, $p < .01$, CFI = .93, RMSEA = .19. Within the baseline model, all parameters were free to be estimated during model fit. The poor fit of the baseline model indicated that some hypothesized effects within the model were not contributing meaningful variance. To improve the model fit, different parameters were set to zero to determine which parameters were contributing meaningful variance. Not all combinations of parameter testing was feasible or statistically sound; the models that were believed to be the most theoretically sound were tested.

The baseline model was compared to four more restrictive models, in order of restrictiveness. Table 5 presents χ^2 difference tests and fit indices for each model. The two factor cross loading indicators model was first tested and χ^2 difference tests suggested an improved fit over the baseline model. The effects of the Early Academics factor on the cognitive and language development measures were then set to zero in the correlated two factor model and results indicated this did not improve fit over baseline. This result suggested that measurement variance was shared between the two latent constructs for both the language and cognitive development indicators. The single factor model was then tested, which restricted the parameters of the Development and Early Academic factors to zero. A χ^2 difference test suggested that the single factor model was significantly different from baseline, but was a poorer fitting model than the baseline model. These results suggest that a single latent construct of School Readiness was not the best explanation of school readiness measures. It further indicated that setting the Development and Early Academics parameters to zero did not further explain measurement variance.

Finally, the higher-order factor model was tested, which was slightly different from the other models in that it was not a more restrictive version of the baseline model. Instead, it examined if a higher order School Readiness factor could underlie both the developmental measures and the early reading and math measures. The model was tested last because this higher order model was a more complicated model, and less parsimonious. It was compared against baseline because a more parsimonious model would be selected over a more complicated model if model fit was similar. Results suggested that the higher-order factor model did not result in improved fit over the baseline model. While the higher-order factor and correlated two factor models differ theoretically, statistically they resulted in the same findings. The School Readiness and Early Academic factors functioned the same in both analysis and the direct effect of the School Readiness factor on the Development factor for the higher order factor model accounted for the same variance as the correlation in the correlated two factor model.

Following model comparison testing, fit indices were compared for the two factor cross loading indicator model, as it was the only model to result in a significantly improved fit over baseline. Fit indices suggested that the two factor cross loading indicators model resulted in the best fit, χ^2 (17, N = 253) = 80.62, p <. 01, CFI = .97, RMSEA = .12. Although the χ^2 was significant for this model, χ^2 is sensitive to sample size and a significant finding with the sample size in this analysis may not reflect a substantive finding (Tabachnick & Fidell, 2013). The CFI, on the other hand, indicates that the model fits well. The ECVI (.47) was the lowest of all five models and so suggested that the two factor cross loading indicators model was the most likely of all the models to generalize and replicate in the population. However, the RMSEA indicated a poor fitting model. For that reason, post-hoc model modifications were performed in an attempt to improve model fit.

Model Modifications

A Lagrange multiplier (LM) test was selected to test model modifications as it is most appropriate for small sample size (Tabachnick & Fidell, 2013). An LM test suggests additional paths that may be added to improve model fit. Based on the LM test in this analysis, covariance paths between residuals of cognitive development and creativity and the arts and between residuals of social and emotional development and creativity and the arts were suggested. The residual covariance suggested extraneous variance in the creativity and the arts measure that was not accounted for by the Development factor. In other words, the creativity and the arts measure may not have been best explained by the Development factor so may not have been a necessary component of the model. Creativity and the arts was removed from the model, resulting in an improved model fit, χ^2 (11, N = 253) = 27.37, $p < .01$, CFI = .99, RMSEA = .08. The CFI indicated that the adjusted model was a good fit and the RMSEA indicated that the adjusted model was an adequate fit.

In addition χ^2 difference tests were run to compare this modified model to both the baseline and original two factor cross loading indicators model. These χ^2 difference tests suggested an improvement both over the baseline model, χ^2 difference (4, N = 253) = 126.88, $p < .01$, and the original best-fit model, χ^2 difference (3, N = 253) = 8.50, $p < .05$. The ECVI (.24) also suggested improved ability to replicate this finding in other studies over the original hypothesized models. The modified two factor cross loading indicators model is presented in Figure 2.

Parameter Estimates

The standardized parameter estimates for the adjusted two factor cross loading indicators model are presented in Table 6 along with standard error and squared multiple correlations. The two factors were moderately correlated (r = .49). All indicators loaded significantly on their respective factors, $p < .01$. The model accounted for a moderate to large amount of the variance in early math scores and a large amount of the variance in all other scores. Social and emotional development was the greatest indicator of the Development factor, followed by approaches to learning, physical development, cognitive development, and language development. Early reading was, in turn, the highest indicator of the Early Academics factor, followed by early math, language development, and cognitive development. Cognitive development and language development loaded more strongly on the Development factor than the Early Academics factor, suggesting that development accounts for a larger proportion of the variance of those scores than early academic skills.

Often times in factor analytic techniques low loading indicators are omitted from the factor to create more parsimonious models (DiStefano, Zhu, & Mindrila, 2009). A common guideline is to exclude factor loadings of .32 or less, which pertains to both the language development and cognitive development variables in this case (Costello & Osborne, 2005; Tabachnick & Fidell, 2013). For that reason, a modified correlated two factor model, presented in Figure 2, was also tested. This model was similar to the correlated two factor model, but excluded the creativity and the arts measure. In this way, the language and cognitive development measures were restricted to the Development factor, so that a model that excluded the low loading indicators from the Early Academic factor could be tested. Fit indices suggested a poor fitting model, χ^2 (13, $N = 253$) = 113.1, $p < .01$, CFI = .94, RMSEA = .17. Therefore, the modified two factor cross loading indicators model was retained as the final model.

Discussion

The purpose of this study was to examine what early childhood skills are important for assessing school readiness. Specifically, it was to define the factor structure of school readiness and to examine a possible method for assessing those skills. Of the five proposed models, the two factor cross loading indicators model best fit to explain kindergarten school readiness in the fall of kindergarten. Based upon this finding, early childhood school readiness measures may represent two latent constructs, Development and Early Academics. These two constructs appear to be moderately correlated and may influence some of the same measures of school readiness, specifically language and cognitive measures.

School Readiness Factors

The reason for a two factor model of school readiness may be two fold. First, theoretically it is understandable that the measures loaded onto the separate factors in the way that they did. Developmental measures tend to be measured together because they are believed to be global indicators of a child's broader development. In that same way, measures that gauge specific early academic skills are likely influenced by a generalized latent factor of academic readiness. Thus, the association between the factors was expected. What was less expected was that these two latent constructs were relatively separate, despite a moderate correlation. A broader latent construct that would explain both skill sets does not appear to be an accurate explanation of early childhood skill development. Based on this analysis, school readiness appears to best be explained as two moderately correlated but separate latent traits.

Second, the way in which the assessments were measured may help to explain the two factor solution. On the one hand, developmental measures are often measured through teacher or parent observation, as they were in this case (Casbergue, 2011). On the other hand, early academic skills are often assessed through direct skill based measures (Cabell, Justice, Zucker, & Kilday, 2009). The shared variance among indicators of each factor may, in part, be due to the measurement method, which is often described as method variance. The possible influences of both the theoretical and measurement characteristics of the indicators are discussed in more detail below.

Development. The Development factor was comprised of five measures of early childhood developmental milestones: social and emotional development, approaches to learning, physical and motor development, language development, and cognitive development. Theoretically, it stands to reason that a single latent construct would underlay these five measures. The five areas of development that were assessed by these measures are often measured together to capture an idea of the whole child in development (LaParo & Pianta, 2000). Each of these areas provides unique information about how the child is functioning in his or her world while still being important to the overall development of the child. These skills appear to develop similarly and tend to be highly correlated (Head Start, 2000; NAEYC, 2009; NEGP,1997; School Readiness Indicators Initiative, 2005). Higher correlations would make sense among the areas. For example, it is not difficult to believe that a child who is open to new activities and curious, meaning they have developed a successful approach to learning, may also have a good deal of problem solving skills and general knowledge, meaning they have high cognitive skills. The results from this study suggest that an underlying factor of Development can help to explain the shared variance amongst measures of developmental milestones.

On the measurement side, all five measures were obtained by teacher ratings of the students within their classrooms. So, the observational method of data collection may explain some of the shared variance between the measures, in addition to the theoretical construct of development. It is possible that part of the shared variance between the measures can be attributed to the way in which each teacher rated each student. Teacher ratings could have varied systematically across classes, if teacher's ratings differed from one another, and across each student, if teachers tended to rate the same student similarly, based upon construct irrelevant details.

Of interest was that the measure of social and emotional development was the greatest indicator of the development factor, with over 90% of the variance in scores explained by development. Based upon this substantial amount of shared variance, the Development factor could potentially be conceived of as an early indicator of interpersonal and work skills, often thought of as soft skills. These skills may help in preparing students to function generally in the formal school environment. The Early Academic factor may be an early indicator of academic skills, potentially conceptualized as hard skills, in contrast to soft skill development. The hard skills may more specifically influence academic performance rather than generalized performance in the school environment. This use of soft and hard skills references both the general nature of the factors and the measurement method. Other indicators of potential soft skills, including approaches to learning and physical and motor development, which include measures of attention and regulation, also loaded highly onto the Development factor. It may be that the same developmental latent construct that influences these developmental measures, also accounts for variance in soft skills, which may want to be investigated in the future.

During model modification, one measure, creativity and the arts, was removed to improve model fit. Creativity and the arts was a measure included in the FAST DevMilestones assessment, but creativity is not often assessed with other measures of development in early childhood (School Readiness Indicators Initiative, 2005). Creativity and the arts may differ from the other developmental measures for many potential reasons, some of which are discussed. First, creativity may not be influenced by the theoretical concept of development, meaning it may not be an area that can be easily tracked in early childhood while large leaps in development are taking place. Second, creativity may not develop in a sequential manner, as some of the other developmental milestones tend to, like language or motor development. Therefore, it may not as easily correlate with specific times in development. Third, it may not be an influential skill in the set up of kindergarten classrooms at the current time, as there increasingly tends to be a focus on academics in kindergarten (Bassok, Latham, & Rorem, 2016). Lastly, the exclusion of creative development may have been an artifact of the sample in this study. Whether creativity is related to developmental measures of school readiness or not, it may still be an important ability to assess within the school setting. Further research should investigate whether creativity should be included into developmental milestone measures or assessed independently though.

Early Academics. Four measures of early academic skills loaded onto the Early Academics factor: early reading, early math, language development, and cognitive development. Similar to the Development factor, theoretically it makes sense that these measures may be indicators of a common construct. Early reading and early math tend to be moderately correlated and strong predictors of each other in later achievement (Cunningham & Stanovich, 1997; Duncan et al., 2007; Hecht et al., 2001; Hooper et al., 2010). Language development influences the development of early reading skills (Briscoe et al., 2001; Lee, 2011; Preston et al., 2010). While the measure of language development also includes pragmatic and functional communication, these two skills would still be expected to share variance. Likewise, cognitive development, as it is defined by early childhood standards, contains a large amount of early math skills (MDE, 2005). So, it would be expected that the cognitive development and early math measures would also share common variance.

On the measurement side, the early reading and early math measures were both direct skill based measures. So, again they may have shared construct irrelevant variance based upon the nature of the assessment. The language and cognitive development measures, on the other hand, are observational rating measures. So, their loadings on the Early Academic factor were more likely to be influenced by the construct itself. These two measures did not load very highly on the Early Academic factor though, which may be partly due to the way in which the assessment was measured. The cognitive and language development measures cross-loaded onto both factors. Together the two factors account for about 80% of the variance of both measures. However, the Development factor appeared to be more influential than the Early Academic factor.

Two overall findings can be drawn from these results. First, school readiness appears to be comprised of two latent factors, a development construct and an early academics construct. So, a theory driven measure of school readiness that includes measures of development and early academic skills was supported. Second, the analysis was able to reduce the amount of parameters that define school readiness from eight down to two. Identifying a factor structure of school readiness and reducing measurement parameters may help to better define and measure school readiness in the future.

School Readiness Implications

The identified model may provide evidence that the definition of school readiness should include a combination of developmental and early academic skills. School readiness is often broadly defined as a set of skills in early childhood that are important for later success (Graue, 2006; Snow, 2006). These results could help to further define that set of school readiness skills as being influenced by two latent factors, underlying the developmental and early academic skill sets. As stated in the introduction, there are limited school readiness measures that assess both the developmental and early academic aspects of school readiness together. Measuring both aspects of school readiness may provide a more complete picture of each student's development. Because of the correlation between the factors and the cross loading of some indicators, it may be even more important to measure these two latent factors together, in a consistent manner.

These results bolster the need for a measure of school readiness that accounts for both developmental and early academic skills.

Practical Implications. Early childhood measures, like those used in this analysis, may provide a comprehensive yet efficient measure of school readiness for early childhood educators to use in the fall of kindergarten. Early childhood measures that include both developmental and early academic domains may aid educators in assessing and understanding individual student school readiness. Measures that are designed to be quick, formative assessments of developing skills sets may add even more utility to measuring school readiness. Efficiency in early childhood settings is valued because of young children's short attention spans and shorter school days (Nelson, 1998). On-line assessments may be helpful in early childhood to increase efficiency in the assessment of young children (Thelwall, 2000). School readiness measures that use both on-line teacher observation ratings and on-line direct skill based measurement may provide a faster way to measure both aspects of school readiness in one assessment. The results of this study helped to showcase that these types of formative measures can provide a comprehensive measure of school readiness.

Early childhood formative assessments are designed for low-stakes, progress monitoring decisions. Therefore, they should not be used as the sole assessment in any high-stakes decision-making. However, the history of school readiness assessments shows that school readiness assessments have tended to be used as gateway assessments to delay school entry in the past (Meisels, 1999; Shepard, 1997). The hope of this study is that the results, in conjunction with future research, may showcase that school readiness can be measured in the fall of kindergarten to serve as a baseline for developmental growth across the kindergarten year. In that way, early childhood educators will have a formative assessment to track school readiness to help prevent delayed school entry or retention in the future.

Limitations. While the results of this study may aid in developing a formative assessment for school readiness, all findings should be interpreted in light of the study limitations. Some limitations were the result of the sample selection process. Participants were recruited from four public schools in Minnesota. The schools were volunteers in the data collection process, as such, the sample can be considered a convenience sample. Each school entered both the demographic data and the data for each measure. So, there was no way to assess the reliability and validity of the data collection procedures. Two of the schools did not enter any demographic data for their students. Therefore, results based upon the demographics of the study were severely limited, as the possible population for this sample, demographically, was somewhat unknown. Because of the sampling and data collection limitation, the generalizability of these results was limited. As such, replication of the selected model in this study is needed.

In addition, because the data were collected from classrooms, the data were hierarchical in nature. The teacher and environment that students within the same classroom share could have influenced both the direct skill based measures and the observational ratings. While steps within the analysis were taken to account for this possible violation of assumptions of independence, the nested data may still have affected the results. As such, a replication of the analysis with a larger amount of classrooms may be helpful in order to be able to include the classroom level data as an effect in the model. The effect of teacher and environment may also add interesting findings to the area of school readiness measurement.

Future Research Directions. The results of this study can be viewed as a small part of a larger collection of studies examining school readiness and school readiness assessment. As such, there are a multitude of future research directions, some of which are described below. Future research should address some of the limitations of this study. Replication is often useful with CFA analysis techniques due to the influence of sample on factor analytic techniques (Tabachnick & Fidell, 2013). The final selected model from this study should be re-examined with larger sample sizes, perhaps in a hierarchical nature. While the confirmed model fit, some of the fit indices indicated only an adequate model, as opposed to a good fitting model. Replication would help to examine the generalizability and validity of the present results. In addition, investigating the role of different demographic information may help to generalize the results of the model further.

The majority of the participants, for whom demographic information was known in this study were American Indian/Alaskan Native (AI/AN) students. There is limited research available concerning school readiness for this population of students. Of the limited research that is available though, Hibel, Faircloth, and Farkas (2008) suggested that school readiness was the best predictor of future special education determination for AI/AN students. Preliminary results of this study suggest that the proposed model of school readiness may be appropriate to measure AI/AN student's school readiness. Further research may want to investigate the utility of this model and possible ways of measuring school readiness in the AI/AN population to help prevent later student difficulties.

One interesting finding of this analysis was the deletion of the creativity and the arts measure from the final model. Future research may investigate how creativity fits into the framework of school readiness and, in the larger sense, with developmental milestones. Examining the best way to measure creativity at early ages may help to illuminate whether or not a measure of creativity is essential for school readiness assessments. In addition, this study restricted data to the individual child level. Future research may want to examine how this model of school readiness fits into a larger ecological context. In other words, investigate how this definition of a student's readiness for school may influence the readiness of the school or community for the child to enter school.

The nature of the measures used in this study also illuminated another potentially interesting area for research in school readiness assessment. The measures that loaded onto the Development factor were observational in nature, while the measures that loaded most highly onto the Early Academics factor were skill based in nature. Future research may want to parcel out the effect of measurement style versus measurement construct on the loading of these two factors. The most appropriate type of assessment for young children is an area of potential disagreement in the field of early childhood (Bradbury, 2014; Casbergue, 2011). Investigation into the roles and influence of measurement style on school readiness skills may add insight into appropriate assessment for young students.

Finally, the present analysis focused on data from the fall of kindergarten in order to specify a possible model of school readiness that may serve as a baseline for later development. Further analysis investigating how these skills develop and influence one another across the kindergarten year may be needed. In this way, a formative assessment that can track these skills as they develop can be used for school readiness.

Conclusion

School readiness has historically been difficult to define and measure. The present study supports a definition of school readiness where two latent factors, Development and Early Academics, explain the variance of school readiness skills in the fall of kindergarten. The two-factor model was shown to adequately fit the data and allowed for a reduction of school readiness indicators. These results may serve as a first step in investigating the development of these school readiness skills across the kindergarten year. Future research hopes to investigate the development of these skills across the kindergarten year in order to support the use of a formative assessment for school readiness.

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Chapter Two Tables

Table 1

Reliability and Validity Statistics of FAST earlyReading and earlyMath Measures

	Reliability			Concurrent Validity	
Measure	α [a]	Split-half [a]	Test-Retest [b]	GRADE	
earlyReading					
Concepts of Print	.75	.76	.42	-	
Onset Sounds	.87	.91	.79	.62	
Letter Names	.98	.99	.94	.41	
Letter Sounds	.98	.99	.92	.53	
Composite	-	-	.91	.68	
earlyMath				MAP	GMADE
Number Sequence	.76	.87	.80	.61	.54
Match Quantity	.80	.87	.76	.40	.47
Numeral Identification	.97	.98	.85	.43	.51
Composite	-	-	.87	.72	.56

Note. GRADE = Group Reading Assessment and Diagnostic Evaluation; MAP = Measures of Academic Progress; GMADE = Group Mathematics Assessment and Diagnostic Evaluation.
[a] For timed measures reliability is based upon items that approximately 84% of students completed. [b] Re-test was administered 2-3 weeks later. Composite is based upon fall-to-winter data. Re-test for the composites are based upon data from one benchmark to the next.

Table 2

Reliability Statistics of FAST DevMilestones Measures

	Reliability	
Measure	α	Test-Retest
Social and Emotional Development	.91	.68
Approaches to Learning	.83	.71
Physical and Motor Development	.73	.58
Creativity and the Arts	.81	.47
Cognitive Development	.88	.77
Language Development	.90	.79

Note. Test-Retest was computed using fall-to-winter data

Table 3

Descriptive Statistics for the Eight Measures of School Readiness

Measure	*M (SD)*	Percentile[a]	Minimum	Maximum	Skewness	Kurtosis
Social and Emotional Development	2.18 (.77)	-	.00	3.90	-.20	-.27
Approaches to Learning	2.01 (.77)	-	.00	4.00	.11	.28
Physical and Motor Development	2.24 (.80)	-	.00	4.00	-.41	.09
Creativity and the Arts	2.06 (.78)	-	.00	3.70	-.07	-.72
Cognitive Development	1.84 (.77)	-	.00	3.50	-.08	-.57
Language Development	2.25 (.88)	-	.00	4.00	-.32	-.22
Early Math	37.19 (11.21)	55th	11.00	67.00	.21	-.14
Early Reading	35.70 (5.50)	65th	23.00	55.00	.40	.05

Note. N = 253. M = Mean; SD = Standard Deviation.

[a] Percentile rankings were not available for DevMilestone subtest composite scores.

Table 4

Pearson's Correlation Coefficients for the Eight Measures of School Readiness

Measures	1	2	3	4	5	6	7	8
1. Social and Emotional Development	-							
2. Approaches to Learning	.86	-						
3. Physical and Motor Development	.81	.79	-					
4. Creativity and the Arts	.73	.81	.73	-				
5. Cognitive Development	.83	.80	.73	.68	-			
6. Language Development	.84	.80	.74	.76	.81	-		
7. Early Math	.36	.42	.27	.39	.50	.51	-	
8. Early Reading	.44	.49	.34	.51	.58	.64	.76	-

Note. $N = 253$. All coefficients were significant at $p < .01$.

Table 5

Summary of CFA Model Testing for Nested Model Comparisons

	Model *df*	χ^2	χ^2 difference test	CFI	RMSEA (90% CI)	ECVI (90% CI)
Hypothesized Models						
Bi Factor (Baseline)	5	154.25*	-	.93	.19 (.17-.22)	.78 (.64-.95)
Two Factor Cross Loading Indicators	7	80.62*	73.63*	.97	.12 (.09-.15)	.47 (.37-.60)
Correlated Two Factor	9	154.60*	0.35	.93	.17 (.14-.19)	.75 (.61-.92)
Single Factor	9	271.27*	117.02* [o]	.87	.23 (.20-.25)	1.21 (1.02-1.44)
Higher Order Factor	9	154.60*	0.35	.93	.17 (.14-.19)	.75 (.61-.92)
Adjusted Models [a]						
Two Factor Cross Loading Indicators	11	27.4*	126.88*	.99	.08 (.04-.11)	.24 (.20-.32)
Correlated Two Factor	13	113.1*	41.15*	.94	.17 (.14-.21)	.57 (.45-.72)

Note. CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; ECVI = Expected Cross-validation Index; CI = Confidence Interval.

[a] Adjusted models were models where the creativity and the arts measure was removed to improve model fit. [0] Indicates a significantly worse fit.

*$p < .01$.

Table 6

Factor Loadings for the Modified Two Factor Cross Loading Indicators Model

Indicator	Development		Early Academics		R^2
	Unstandardized (*SE*)	Standardized	Unstandardized (*SE*)	Standardized	
Social and Emotional Development	1.05 (.04)	.95			.91
Approaches to Learning	.96 (.04)	.90			.82
Physical and Motor Development	.94 (.04)	.86			.74
Cognitive Development	.81 (.04)	.76	.03 (.01)	.22	.79
Language Development	.89 (.04)	.74	.05 (.01)	.30	.84
Early Math			1.64 (.12)	.78	.61
Early Reading			.61 (.05)	.97	.95

Note. *SE* = Standard Error; R^2 = Squared Multiple Correlation. All factor loadings were significant, $p < .01$.

Chapter Two Figures

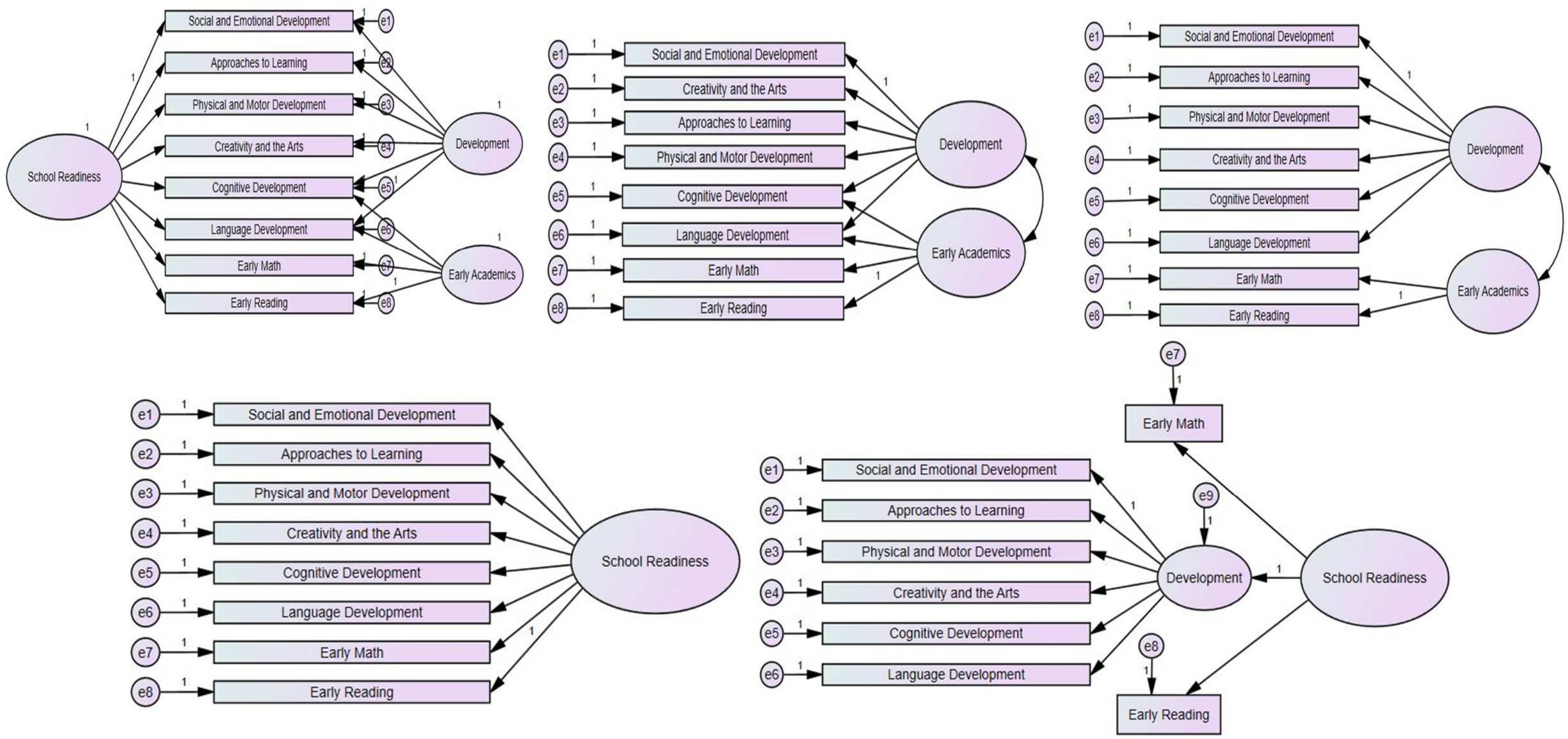

Figure 1. Five hypothesized factor models. Models run left to right, starting with model one in the upper left corner. Latent constructs are represented by circles and observed variables are represented by rectangles. Circles labeled with “e” represent residual error for the dependent variables

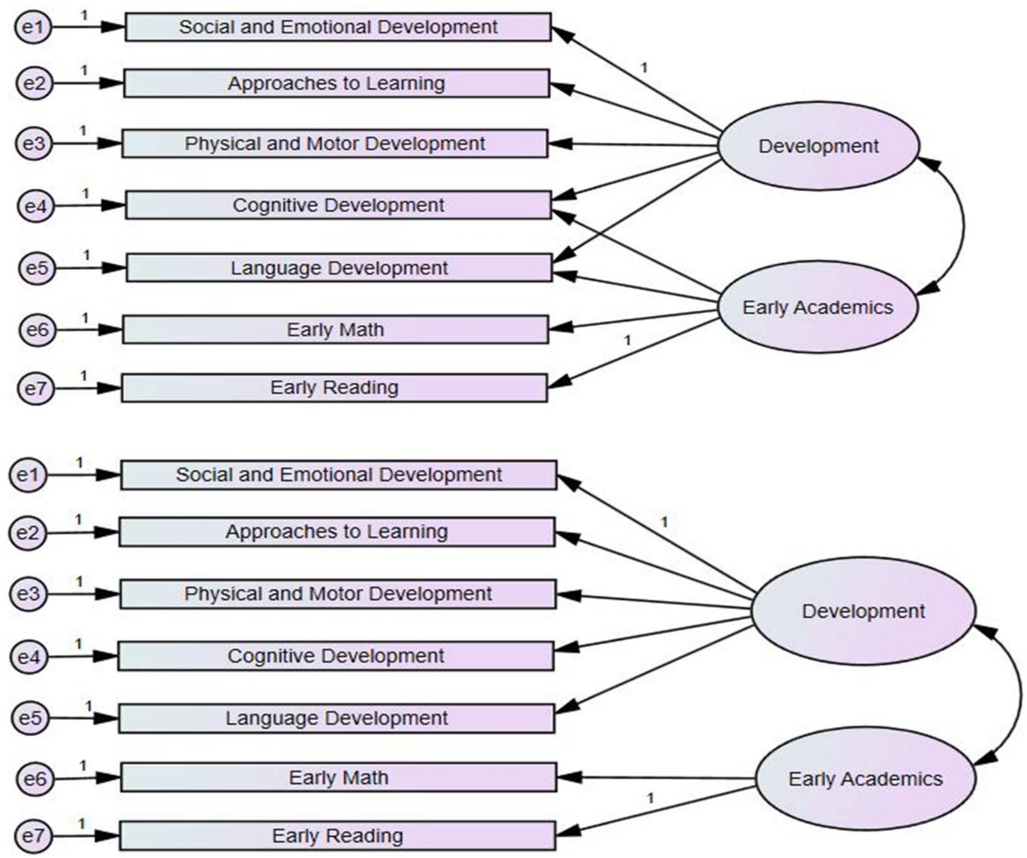

Figure 2. Adjusted two factor cross loading indicators model (top) and adjusted correlated two factor model (bottom). Latent constructs are represented by circles and observed variables are represented by rectangles. Circles labeled with "e" represent residual error for the observed variable.

Chapter Three

School readiness is often conceptualized as a combination of achievement in developmental milestones and early academic skills (Dickinson & McCabe, 2001; Duncan et al., 2007; Head Start, 2000; National Association for the Education of Young Children (NAEYC), 2009; National Reading Panel, 2000; National Education Goal Panel (NEGP), 1997; School Readiness Indicators Initiative, 2005; Snow, Burns, & Griffin, 1998). Children who were “ready for school” have been shown to have increased academic and social success later in life (Cunningham & Stanovich, 1997; Hecht, Torgesen, Wagner, & Rashotte, 2001; Hooper, Roberts, Sideris, Burchinal, & Zeisel, 2010; NAEYC, 2002; Reschly, 2010; Reynolds, Rolnick, Englund & Temple, 2010; Snow, 2006). Therefore, measuring and supporting the development of these skills has been proposed as a preventative approach to later educational difficulties (National Institute of Mental Health, 2002; National Research Council & Institute of Medicine, 2001; Reynolds et al., 2010; School Readiness Indicators Initiative, 2005).

Limited research is available, though, on how to assess school readiness skills and track progress in the development of those skills (Meisels, 1999). Formative assessment of school readiness skills may provide educators the data necessary to make those educational decisions. Before developing a formative assessment of school readiness, though, it is important to investigate how school readiness skills would best be assessed in an appropriate and efficient manner while still providing information about future achievement.

History of School Readiness Assessment

Historically, the definition of school readiness, and by extension school readiness assessments, have transitioned through four major theoretical perspectives. Meisels (1999) outlines these transitions, which are briefly discussed here. School readiness was initially conceptualized as a maturational process where children naturally developed the ability to benefit from school. Meisels (1999) referred to this approach as the Idealist/Nativist approach. Within this approach, children who were not ready for school were believed to need time to develop those abilities (Carlton & Winsler, 1999). Therefore, assessments were used to screen children out of school that were not yet ready. Those children were then instructed to wait until they naturally developed the skills necessary for schooling, which was often referred to as "the gift of time" (Shepard, 1997). The Gesell School Readiness Test (GSRT; Ilg & Ames, 1972) was traditionally used in this manner and held a number of children out of school over the years (Shepard, 1997).

The second perspective, which Meisels (1999) referred to as the Empiricist/Environmental prospective viewed school readiness as a collection of skills that the child has learned that will lead to later achievement. In essence, the school readiness pendulum swung in the opposite direction during this transition. School readiness was completely dependent on what the child had learned and did not include any maturational development (High, 2008). However, assessments were still used in much the same way, to place children in different school contexts. The theoretical reason children were not ready for school had changed from maturational to environmental; but children who were not exposed to those learning opportunities were still either held out of kindergarten to obtain those skills or retained in kindergarten for an extra year (Shepard & Smith, 1986).

With the transition to the third perspective, Social Constructivist, context was considered in the definition of school readiness (Meisels, 1999). Under this perspective, school readiness was defined as the school and communities readiness to educate children when they arrive at school. As such, assessment focused on understanding and developing the setting in which the child learned (Carlton & Winsler, 1999). One widely used assessment that operates from this perspective is the Classroom Assessment Scoring System (CLASS PreK; Pianta, La Paro, & Hamre, 2005), which measures teacher and classroom support of student's learning.

The fourth, and current, conceptualization of school readiness comes out of the Interactionist perspective (Meisels, 1999). Similar to the Social Constructivist perspective, the Interactionist perspective recognizes the importance of learning environments for children's school readiness. It also acknowledges, though, the importance of children's school readiness skills. School readiness is viewed as an interaction between the child and the school to develop the skills necessary for future academic success (High, 2008). Under this perspective, readiness can only be assessed within the learning context and over time as the student develops his or her skills. Therefore, this perspective lends itself to using a formative assessment approach to measuring school readiness.

Current school readiness assessments do not provide a formative approach to measuring school readiness though. Instead, these assessments are often used to screen children before entering kindergarten, to determine educational placement (Shepard, 1997). This approach to school readiness has the possibility of limiting student's academic gains and has created contention in the discussions around school readiness assessment.

Kindergarten Screenings. When used within a formative assessment system, universal screening is important as it provides a global indication of the functioning of a school and helps to identify individuals in need of more support (Ikeda, Neessen, & Witt, 2008). However, universal screening needs to be paired with differentiated instruction and progress monitoring for those who need more substantial support. The danger with kindergarten screeners is that readiness is often defined as a single threshold for entering kindergarten (Meisels, 1999). In the past, students have been screened and then advised to wait to enter kindergarten if they do not do well on the screener (Frey, 2005). These practices have limited children's opportunities to learn and negatively impacted the enrollment of minority students (Frey, 2005; Meisels, 1999). In addition, assessment in this manner has introduced high-stakes testing into early childhood and shaped the educational curriculum, instead of measuring attainment in that curriculum (Meisels, 1999).

The American Academy of Pediatrics (1995) and the National Association for the Education of Young Children (NAEYC; 2009) both released policy statements regarding kindergarten screeners. The American Academy of Pediatrics stated that all children who reach the legal age for school are entitled to an education. Kindergarten screeners can be useful for screening for possible developmental delays, but they should not be used to exclude students from school or place students in different educational environments (1995). NAEYC stated that entry into school should be based upon age and not mastery of skills. Students who lack school readiness skills need access to resources to help develop those skills and need to be monitored in skill development to help prevent retention in kindergarten (2009). Kindergarten screeners that are used inappropriately have led a number of students to delay school entry, which can negatively impact their educational outcomes.

Delayed School Entry. Delayed school entry, also referred to as "Academic Red-Shirting", is based upon the idea that holding children back from school allows them the time to mature and naturally develop school readiness skills (Frey, 2005; Raffaele-Mendez, Sook-Kim, Ferron, & Woods, 2015). Approximately 9% of students were delayed in their school entry in the 2010-2011 school year, the most current data available, which is defined as starting kindergarten at age six (NCES, 2011). Children that had delayed entries were more likely to be white males and come from higher income families (Frey, 2005; Raffaele-Mendez et al., 2015). Parents were more likely to delay school entry if their child showed less mature behaviors than others his or her age or was born during the summer months, meaning they would be among the youngest in the class (Frey, 2005; Raffaele-Mendez et al., 2015).

Delayed school entry has been linked with negative school outcomes later in a child's academic career. One study found that students who delayed school entry had lower scores on math, reading, and writing tests and lower teacher ratings on attention at age eight than students that had typical school entry (Jaekel, Strauss, Johnson, Gilmore, & Wolke, 2015). These students were also more likely to exhibit bully and bully-victim behaviors (Crothers et al., 2010). Negative effects of delayed school entry also seem to last into adulthood. Lincove and Painter (2006) found that the students in their sample with delayed school entry were more likely to be retained in grades 1-8 and twice as likely to drop out of high school. In adulthood, these students were less likely to attend college, earned lower salaries, and were more likely to be incarcerated.

Part of the reason that children who delay school entry may have lower academic outcomes is that they may begin school with fewer school readiness skills than children who began kindergarten on time. Many of the studies that examine issues of delayed school entry attempt to control for these differences (Raffaele-Mendez et al., 2015). However, if this were the case, then providing these students with educational opportunities and possible intervention sooner rather than later could be helpful (Shepard & Smith, 1986). Holding children out of school does not increase educational outcomes as the advantages of schooling outweigh the advantages of chronological age (Meisels, 1999; NAEYC, 2009). Using formative assessment to track progress in school readiness skills would most likely increase student outcomes at a greater rate than using these assessments to screen children out of kindergarten. Monitoring progress across the kindergarten year and adjusting instruction based upon this data could also help to prevent another educational decision that has potential negative effects, kindergarten retention.

Kindergarten Retention. Students who are retained in kindergarten tend to have worse academic outcomes than children who start school on time or those that enter school delayed. Students retained in kindergarten were more likely to be identified for special education, have lower standardized test scores, and have poorer attitudes to school (Raffaele-Mendez et al., 2015). Similar to students who delay school entry, students who were retained in kindergarten also tended to engage in more bully and bully-victim behaviors. Retained kindergartners were shown to have the highest levels of verbal, relational, and physical bullying behaviors as well as more provocative victim behaviors (Crothers et al., 2010).

There also appears to be a socioeconomic difference between children who were retained and those that were delayed in their school entry. Retained students were more likely to have free-or-reduced price lunch and were more likely to be African-American (Raffaele-Mendez et al., 2015). As stated above, children with delayed school entry tended to be white middle class males (Frey, 2005; Raffaele-Mendez et al., 2015). One explanation for this difference may be that some parents can afford to keep their children out of kindergarten for a year while other parents can not afford to take on the child care costs of not having their child in kindergarten. As retained students tend to have the worst outcomes, this could increase an already present achievement gap (Shepard, 1997).

Entering kindergarten is a process; it is not established on the first day of school (Belfield & Garcia, 2014; Frey, 2005). Attaining the early childhood skills necessary to access the kindergarten curriculum is only one part of school readiness. Developing those skills throughout the kindergarten year is also important (NEGP, 1997). Students continue to develop throughout the kindergarten year and monitoring their progress in the development of those early school skills could help educators plan programming and supports to help prevent later academic difficulties (National Institute of Mental Health, 2002; National Research Council & Institute of Medicine, 2001; Pianta, Rimm-Kaufman, & Cox, 1999).

Formative Assessment of School Readiness

Formative assessments are used to inform teaching and embed data-based decision making into the classroom context (Meisels, 1999; Shinn, 2008). Curriculum-based measurement (CBMs) provides a way to formatively assess student skill development over time, while still providing reliable and valid data (Deno, 1985). Creating valid measures of student progress in the educational curriculum can help improve student outcomes (Reschly, 2008). Just as in K-12 education, progress monitoring in early childhood provides important data on child development over time, identifies students not responding to interventions, and helps to evaluate program effectiveness (Daily, Burkhauser, & Halle, 2012; Greenwood et al., 2008). Progress monitoring is especially helpful in early childhood education because of the rapid skill development in young children (NEGP, 1997). Yet, there are few CBMs for early childhood skills in general and none available to track the development of a comprehensive set of school readiness skills (McConnell & Missall, 2008).

In 2005, the School Readiness Indicators Initiative called for the creation of measures to track progress towards school readiness. They indicated that the creation of these types of measures was the first policy step toward getting children ready for school.

In order to be effective, a formative assessment of school readiness would most likely need to have certain characteristics. First, the assessment system would engage students with work tied to the students' curriculum (Deno, 1985; Meisels, 1999). Second, it should provide teachers with a sufficient amount of data that is sensitive to growth in students and predictive of future outcomes (Deno, 1985; Gallagher, 1999; Meisels, 1999). Third, the ideal system would provide an efficient and cost-effective way to screen and progress monitor kindergarten students (Deno, 1985). Finally, the system would need to be appropriate for young children (Bradbury, 2014; Meisels, 1999). The best approach for measuring students' skills to include these characteristics is still unclear though (Meisels, 1999).

Approaches to Measuring School Readiness

A debate exists in early childhood assessment between proponents of direct skill-based assessment and observational assessment (Bradbury, 2014; Casbergue, 2011). Proponents of observational assessment have argued that it is an authentic measure of behaviors that is less intimidating for young children (Bradbury, 2014). Yet, limited research is available on if observational data collected from teachers is sufficient in predicting future academic success, without the added information that direct assessment provides. Insufficient assessment practices can result in wasted instructional time and inappropriate service allocations, so determining a valid approach is important (Schappe, 2005).

Observational Assessment. Observational assessment consists of teacher's ratings of student skills in developmental milestones (Bradbury, 2014; Goldstein, Eastwood, & Behuniak, 2014). Observations are often the preferred method of assessment in early childhood as it is considered more developmentally appropriate (Gestwicki, 2013). As standardized testing is increasingly more commonplace in elementary school, some advocate for keeping direct skill measurement out of early childhood and elementary classrooms (Meisels, 2007). The fear is that the increasing expectations and pressure that can result from standardized testing will limit developmentally appropriate practice (Gestwiki, 2014).

Observational assessment may be able to prevent a narrowing of the curriculum by allowing teachers to assess a wide variety of skills. Direct skills-based assessment often measures constrained skills, or skills that a student either knows or doesn't know (Casbergue, 2011). For example, a student only learns the names of letters once, and then that skill has been mastered. On the other hand, observational assessment more easily captures skills that continue to develop throughout a student's educational career, like social skills or vocabulary (Casbergue, 2011). Observational assessment has also been shown to be less likely to be influenced by child characteristics, like fatigue and distractibility, which often influence early childhood assessment results (Cabell, Justice, Zucker, & Kilday, 2009). Observations can be conducted across multiple settings and times to provide a more accurate depiction of student skills (Cabell et al., 2009).

Teachers also sometimes prefer observational data collection to direct assessment. Teachers indicated that observational data were more reflective of skills within context and was a better indicator of a student's ability to generalize important skills (Casbergue, 2011). Teachers have also noted that they appreciated the ability to use their professional judgment in determining students' school readiness skills (Cabell et al., 2009).

Is it Accurate? Observational assessments may introduce additional error in measurement due to their reliance on teacher ratings though. Teacher ratings have been shown to vary based upon certain construct irrelevant characteristics. Alvidrez and Weinstein (1999) showed that socioeconomic status is a significant predictor of teacher ratings of intelligence, after actual intelligence levels were controlled for. Underestimation of skills was then linked to high school GPA, meaning that teacher's expectations of students was more predictive than student's intelligence level (Alvidrez & Weinstein, 1999). Rimm-Kaufman, Pianta, and Cox (2000) showed that non-minority teachers tended to rate minority and non-minority students differently, while minority teachers rated students similarly.

The types of skills being measured also tended to affect teacher ratings. Younger teachers tended to be more concerned with academic skills, while older teachers focused more on social skills, approaches to learning, and physical health (Lin, Lawrence, & Gorrell, 2003; NCES, 1993). Overall teacher ratings on all measured skills were influenced by students' development of the particular skills that were most important to the teacher (Lin et al., 2003). Student's who were creative, verbally fluent, independent, and open to new activities were consistently rated as more intelligent than their scores on cognitive assessments suggested (Alvidrez & Weinstein, 1999). Conversely, students were rated as less intelligent by teachers, than their cognitive scores indicated, when they preferred non-verbal communication, looked to adults for help, and were victims of bullying behavior (Alvidrez & Weinstein, 1999). Teachers also tended to rate observable behaviors more accurately than non-observable behaviors (Cabell et al., 2009).

Limitations. In addition to concerns about the validity of observational assessment, there are some logistical concerns that may limit its utility. Bradbury (2014) conducted an ethnographic look at a set of schools using observational data to rate school readiness skills. The teachers in the study reported that it was difficult to reduce a large number of observations into a single rating. Collecting observational data across the school year was time-intensive and resulted in some teachers rushing through the ratings without carefully considering each student (Bradbury, 2014). Some teachers also felt pressure from their administration or district to rate student's in a certain way (Bradbury, 2014).

Given that teacher ratings can at times be swayed by non-relevant student characteristics, the types of decisions that are based upon this data should be carefully considered. This is especially true considering the negative ramifications of delayed school entry and kindergarten retention, which were discussed earlier. Yet when teachers have been asked about school readiness, 73% do not think all students are school ready by the end of kindergarten year and 70% said that they would retain those students (NCES, 1993). Furthermore, 85% of kindergarten teachers share their thoughts on students with the student's first grade teacher, indicating that those observations follow students past the kindergarten year (NCES, 1993). Direct skill-based assessments are available to supplement those observations, but limited research has investigated if observational data produces information above and beyond direct skill based measures.

Direct Skill-Based Assessment. Observational assessment is typically considered best practice in early childhood assessment (Bradbury, 2014; Casbergue, 2011; Gestwiki, 2013). However, as outlined above, it comes with certain limitations that may restrict its validity. There is some evidence to suggest that directly measuring certain skills in addition to observational assessment may provide additional needed information (Alvidrez & Weinstein, 1999; Cabell et al., 2009). Early reading and early math skills are often assessed through direct skill based means. These skills have been shown to be the best predictors of later academic success, beyond other cognitive, behavioral, and environmental factors and across different populations of students (Cunningham & Stanovich, 1997; Duncan et al., 2007; Hecht et al., 2001; Hooper et al., 2010). Similarly, low early academic skills were shown to be the best predictor of later grade retention in elementary school (Davoudzadeh, McTernan, & Grimm, 2015).

When assessed through teacher ratings, low ratings on early reading and early math skills were more indicative of kindergarten retention than language or personal skills (Goldstein et al., 2014). Yet, direct assessment of these skills has been shown to be better at predicting later academic achievement than these teacher ratings (Alvidrez & Weinstein, 1999; Cabell et al., 2009). Correlations of direct assessment of these skills and teacher ratings have ranged from $r = .35$ to $r = .60$ (Cabell et al., 2009; Schappe, 2005). When teachers were asked to classify students into high risk and low risk groups, they were only able to classify at a rate that was a 3.8% improvement over chance (Cabell et al., 2009). Research has yet to be conducted on if adding a direct skill measure to these teacher observations would improve predictive power for young children.

The development of a formative assessment for school readiness would be improved by determining which skills best predict academic success over the kindergarten year and what is the most efficient way to measure these skills while still being valid. Past research has highlighted the importance of observational assessment in early childhood (Bradbury, 2014; Gestwiki, 2013; Goldstein et al., 2014). Therefore, including teacher ratings in the assessment may be the best place to start. However, research is still needed on the relative importance of direct skill based assessment versus observational assessment for a formative measure of school readiness.

Purpose Statement

The purpose of this study was to explore an efficient way to measure school readiness across the kindergarten year. Specifically, it was to investigate which school readiness skills at fall and winter benchmarks best predicted end of year kindergarten academic achievement. It was expected that developmental milestone measures would predict end of kindergarten early academic skills, in addition to the variance accounted for by early academic measures.

Methods

Participants

A total of 77 students were administered FAST assessments across the kindergarten year. Half of the students were male (n = 38, 49%). The majority of students were five-years-old (n = 63, 82%) in the fall of kindergarten; the remainder were six-years-old (n = 14, 18%). All participants attended one of four classrooms in an elementary school in northern Minnesota. Participant demographics were not provided by the school, which is further discussed in the limitations section. Demographics from the school as a whole for the year are provided in lieu of participant information (NCES, 2014-2015). The majority of students enrolled in the school were White (94%), followed by Mixed Race (4%), Hispanic (1%), American Indian/Alaskan (<1%), Asian/Pacific Islander (<1%), and Black (<1%). A little more than half of students qualified for free-or-reduced lunch (57%), as such, the school had a Title I program.

Measures

Participants were administered FAST earlyReading, earlyMath, and DevMilestones in the fall and winter of the kindergarten year. EarlyReading and earlyMath were administered in the spring (Christ et al., 2015). EarlyReading and earlyMath composite scores were used at each benchmark time (i.e., fall, winter, and spring). Composite scores were based upon the subtests that best represented achievement at the time to increase efficiency and account for development of skills across the year. Each of the three measures is discussed below, with explanations of changes in composite scores across benchmark times. Psychometric statistics for earlyReading are presented in Table 1, earlyMath are presented in Table 2, and DevMilestones are presented in Table 3.

earlyReading. The FAST earlyReading assessment was comprised of ten subtests designed to cover four domains of early reading development: concepts of print, phonemic awareness, phonics, and decoding. Composite scores across the kindergarten year were comprised of different combinations of these subtests. EarlyReading was administered at three benchmark times throughout the kindergarten year: fall, winter, and spring.

Kindergarten Fall Composite. Four subtests were included in the fall composite score and are described below. Composite scores were constructed using weightings, based upon previous factor analysis studies (Christ et al., 2015). The value of the factor scores used to create the composite were not widely available, but the magnitude of the weighting was as follows: high weighting of concepts of print, moderate weighting of onset sounds, and low weightings of letter names and letter sounds. Composite scores at or below 34, representative of the 40th percentile, indicate some risk for future reading difficulty and scores at or below 29, representative of the 20th percentile, indicate high risk.

Concepts of Print. The concepts of print subtest included items that assessed if the participant understood the conventions of reading. Included in this subtest was knowing how to hold a book, understanding that printed text holds meaning, reading from left to right, and understanding punctuation. The subtest was not timed but typically takes one to two minutes to complete. A timer is included in the on-line platform in order to assess fluency. Scores can be reported as percent accuracy, items correct per minute, and total items correct. Scores of total items correct were included in the composite and possible scores ranged from 0-12.

Onset Sounds. During this subtest, participants were shown a set of four pictures and asked to select the picture whose name began with the same sound the administrator was saying. This subtest was also not timed and typically takes two minutes to complete.

Again, a timer is included in the on-line platform in order to assess fluency. Scores can be reported as percent accuracy, items correct per minute, and total items correct. Total items correct scores were included in the composite and possible score range was from 0-16.

Letter Names. Participants were asked to name upper and lower case letters in isolation. They were given one minute to name as many letters as they could. Scores can be reported as percent accuracy, items correct per minute, and total items correct. Total items correct scores were included in the composite score. The student was provided 100 letters to see how many he or she could name in a minute.

Letter Sounds. Similar to letter names, participants were asked to say the sound associated with upper and lower case letters, which were presented in isolation. They were given one minute to name as many letter sounds as they could. Scores can be reported as percent accuracy, items correct per minute, and total items correct. Total items correct scores were included in the composite score. The student was provided 80 letter sounds that could only be pronounced in one way (i.e., /B/, /k/). If the student completed all 80 sounds before the one minute, they were also presented with 28 dual letter sounds (i.e., /Ē/, /ă/) to name within the minute.

Kindergarten Winter Composite. The winter composite score was based on scores from onset sounds and letter sounds, like the fall composite. It also included scores from the word segmenting and nonsense words subtests, described below. The weighting of the subtests also differed between the fall and winter composites. The onset sound subtest was highly weighted, the nonsense words subtest was moderately weighted, and the letter sounds and word segmenting weighting was low. In the winter, composite scores at or below 51 indicate some risk and scores at or below 44 indicate high risk.

Word Segmenting. The opposite of word blending, participants were asked to give the individual phonemes of a given word. The subtest was untimed and open-ended, but typically takes one minute to administer. Scores can be reported as total items correct and percent accurate. Possible scores ranged from 0-34.

Nonsense Words. Items consisted of consonant-vowel-consonant or vowel-consonant pseudowords. Participants were instructed to decode the string of letters, in order to gain a measure of decoding skills without possible familiarity effects. Participants were given one minute to read as many of the 50 presented words as possible. Scores can be reported as percent accuracy and words correct per minute. Words correct per minute scores were used in the composite score.

Kindergarten Spring Composite. The spring composite included letter sounds, word segmenting, and nonsense words, like the winter composite but also included a measure of sight word knowledge. The weighting of subtests on the composite score differed from the winter composite; moderate weighting of word segmenting and nonsense words subtests and low weighting of the letter sounds and sight words subtests. Scores at or below 64 indicate some risk and scores at or below 56 indicate high risk.

Sight Words. Participants were assessed on their ability to recognize with automaticity common high-frequency words. They were instructed to read a word list of the 50 easiest and highest frequency words, based upon an analysis of word difficulty. Participants were instructed to read as many of the words as they could within one minute. Scores can be reported as words correct per minute and percent accurate. Possible scores ranged from 0-50, and words correct scores were used in the composite score.

earlyMath. The FAST earlyMath assessment was comprised of ten subtests intended to measure three broad domains of early math: Number, Relations, and Operations. Again, the composite scores across the kindergarten year were comprised of different combinations of these subtests. EarlyMath can be administered at three benchmark times throughout the kindergarten year (i.e., fall, winter, and spring).

Kindergarten Fall Composite. Three subtests were included in the fall composite score and are described below. Composite scores were again constructed based upon weightings from previous factor analysis studies (Christ et al., 2015). Number sequence was weighted highly in the composite score, match quantity was weighted moderately, and numeral identification was lowly weighted. A composite score at or below 34 indicated some risk of later math difficulty and a score of 27 or below indicated high risk for later difficulties.

Number Sequence. The number sequence subtest was a measure of participant's understanding of the mental number line. Participants responded to four types of questions within this subtest. Count sequence items instructed the participant to verbally count forwards or backwards, given three consecutive numbers by the examiner. Number after items, number before items, and number between items included questions related to assessing how numbers relate to one another on the number line. The subtest was an open-ended, untimed measure, which typically takes 1-2 minutes. Scores for this subtest can be reported as items correct and percent accurate. Items correct was used in the composite score and possible scores ranged from 0-13.

Match Quantity. Participants were asked to match an array of dots with one of four numerals presented. Dot arrays were both configured and random, and participants were given one minute to complete as many items as they could. Scores can be reported as percent accurate, items correct per minute, and total items correct. Possible scores ranged from 0-20.

Numeral Identification. Participants were instructed to name as many numerals as they could within one minute. All numerals between 0 and 31 were used and numerals were presented in a non-sequential order. Scores can be reported as percent accurate and items correct per minute. Students are provided 110 numerals to identify within the one minute.

Kindergarten Winter and Spring Composite. The winter and spring composite scores were made up of the same subtests. The composites included two subtests from the fall composite: numeral identification and number sequence. They also included a measure of decomposing, described below. The weighting of each of the subtest scores into the composite score was also the same across both benchmarks, including high weightings for the decomposing and number sequence subtests and low weightings for the numeral identification subtest. In the winter, a score at or below 54 indicated some risk and a score at or below 31 indicated high risk. In the spring, a score at or below 63 indicated some risk and, again, a score at or below 31 indicated high risk.

Decomposing. Participants were shown a row of five or ten foods and the examiner said, “I ate X, how many are left?” Half of the items required decomposing from five and the other half from ten. Participants were not allowed to use counting strategies to solve the problem. The subtest was an open-ended, untimed measure, which usually takes 1-2 minutes. Scores can be reported as percent accurate and total items correct. Possible scores ranged from 0-8.

Developmental Milestones. FAST DevMilestones were used to track participants’ acquisition of developmental milestones across the kindergarten year. DevMilestones is a criterion-referenced rating scale of student’s development across six school readiness domains. Each teacher rated participants’ performances in each domain based upon informal observations of the student. Forty-three items in all were rated at each benchmark time, divided among the six domains, which are available in Appendix A. However, only thirty-nine of the items were used in the analysis, as the creativity and the arts subtest was removed. Available reliability statistics are presented in Table 3. DevMilestones was not available for commercial use at the time of this study, so reliability and validity statistics were still pending.

Ratings were on a five point scale where teachers selected one of the following: Not yet at first level (0), Inquiring (1), Emerging (2), Incorporating (3), Mastering (4). Each item was rated from 0-4 and the scores were averaged across the total number of items to derive the student’s score for that domain; therefore, scores ranged from 0-4. Support for use of creating composite scores off of item ratings was based upon a previous confirmatory factor analysis, χ^2 (751) = 2283.394, $p < .01$, CFI = .92, RMSEA

= .09. These results suggested an adequate fit, and that DevMilestones is comprised of six factors, with items for each domain loading onto its respective factor. It should be noted that the results from study one did not support the inclusion of creativity and the arts, so it was removed from analysis. The domain is still explained below to provide an explanation of the type of information excluded.

Social and Emotional Development. Seven items were rated to assess each participant's Social and Emotional Development. The items in this domain rated each participant's understanding and maintaining of reciprocal relationships, emotional awareness and regulation, and self-confidence and independent engagement.

Approaches to Learning. The Approaches to Learning domain was made up of six items. The assessment measured the student's curiosity, risk taking, imagination, and persistence with tasks. It also contained items that examine the student's adaptability to change and the way the student learns from previous experiences.

Physical and Motor Development. Six items assessed the student's Physical and Motor Development. The items in this domain focused on gross and fine motor development as well as the student's understanding and engagement in healthy lifestyle habits.

Creativity and the Arts. Four items comprised the Creativity and the Arts domain. Creativity, through this assessment, was measured by examining the student's use of media, skills, and resources to independently complete artistic tasks. It also examined the student's interest in and opinions about artwork.

Cognitive Development. Ten items also comprised the Cognitive Development domain. Items on this measure included early geometry and number concepts, problem solving skills and environment exploration, and basic general knowledge about the community. The measure also assessed the child's memory and scientific approach to tasks.

Language, Literacy, and Communication. Ten items comprised the Language, Literacy, and Communication domain; from here on out referred to as Language Development. The items involved conventional and pragmatic language, social communication, and some early reading skills. The domain also included items that examine interest and motivation for engaging in conversation and reading.

Procedures

Data were collected for each participant, at each benchmark time-point, by his or her school, while attending public kindergarten classrooms. Each student's data were collected and uploaded by the school, using the FAST Bridge to Learning on-line platform. Teachers were trained on both the assessments and on-line platform through the FAST training procedures available on-line. These data were collected after request from the Minnesota Department of Education (MDE) for public kindergarten classrooms to collect student level achievement in early reading, early math, and developmental milestones. It should be noted that classrooms were required by the state to collect DevMilestones data in the fall and winter benchmark times but not in the spring, so no data were available. The earlyReading and earlyMath measures were collected through one-on-one skill based assessment, using both on-line and paper and pencil tasks. All scoring was completed on-line. The DevMilestones data were collected through teacher observations at three benchmark times, based upon observations from the previous time period. Teachers were instructed to rate students following a six-week period of initial observations at the beginning of the year, for the fall benchmark. All ratings were completed for each student using the on-line DevMilestones platform. Data were obtained through request from the FAST Bridge to Learning system and available demographic information, composite scores, and domain scores for each measure were supplied.

Analysis. Path analyses were conducted through IBM SPSS AMOS 23 to assess a possible model of school readiness development across the kindergarten year. Three aspects of school readiness, development, early reading, and early math, were used as the measured variables in the analysis. Composite scores based off of a confirmatory factor analysis (CFA) conducted in study one were used as the measured variable for the development data. Composite scores were obtained by summing the scores of the observed measures comprising the factor. Fit indices indicate that a two factor cross loading indicators model provided an adequate fit, χ^2 (11, N = 253) = 27.37, p <. 01, CFI = .99, RMSEA = .08. For this model, the two factors were Development, including five measures of early childhood development (i.e., language, cognitive, social and emotional, physical, and approach to learning) and Early Academics (i.e., early reading, early math, cognitive development, and language development).

Of interest in this study was to examine the added variance explained in early academic achievement by developmental measures. Therefore, only the Development factor was used in the second study. The Early Academics factor included the cognitive and language development assessments. In order to maintain a measure of only direct skill based academic skills, the individual early reading and math assessment data were used in the study instead. Because of the exclusion in this study of the Early Academics factor from study 1, a CFA was run on only the developmental measures to assess the fit of those measures loading on only the Development factor. Fit indices suggested a good model fit, χ^2 (5, N = 253) = 6.1, p = .29, CFI = .99, RMSEA = .03, indicating that the Development factor could stand alone. Table 4 provides the significant factor loadings of both the final model selected in study one and the Development factor only model presented here.

Similar to study one, multiple models were tested in order of least to most restrictiveness, as a way of comparing nested models (McDonald & Ho, 2002; Rindskopf & Rose, 1998; Senn, Espy, & Kaufmann, 2004). Model fit was assessed by examining χ^2 probability and difference tests. With path analysis techniques, a non-significant χ^2 suggests that the hypothesized model does not differ from the population model. In other words, that the model fits the population of students. Model fit was also assessed with the following goodness-of-fit criteria:

1) Comparative Fit Index (CFI): A ratio of the fit of the estimated model over the null hypothesis model. CFI values greater than .90 indicate an adequate fit and values above .95 indicate a good fit (Hu & Bentler, 1999; Tabachnick & Fidell, 2013).

2) Root Mean Square Error of Approximation (RMSEA): A calculation of the lack of a good fit compared to the saturated (or ideal) model. RMSEA values below .08 indicate an adequate fit and values below .06 indicate a good fit (Browne & Cudeck, 1993, Hu & Bentler, 1999).
3) Expected Cross Validation Index (ECVI): A measure of the extent to which a model can be replicated with a different sample. No clear cut-offs are established but the lower the value, the better the replication possibilities, when comparing across models (Sawaki, Stricker, & Oranje, 2009).

Models that included development and early academic measures in fall, winter, and spring were conducted to examine the variance accounted for in spring early academic measures by fall and winter measures. A baseline model was initially run, where all possible parameters were freely estimated (Streiner, 2005). Hypothesized and alternative models were then compared to this baseline model. Chi-squared difference tests were used to determine if a nested model was a significant improvement over the baseline model. The hypothesized path analysis models are presented in Figures 1 and 2. A single headed arrow represents a hypothesized direct effect and a double-headed arrow represents a hypothesized correlation between variables.

Maximum likelihood estimation was used to estimate model parameters. Student-level data were nested within four classrooms. Due to the small number of classrooms, the data were collapsed across classrooms. An intraclass correlation was attempted but not obtained for classrooms due to the lack of variance between groups, which further supports the decision to collapse the data. However, because of the possible violation of independence, the Bollen-Stine bootstrap was used. The Bollen-Stine method of bootstrapping was selected because it has been shown to better correct for possible data violations than Satorra-Bentler scaling or maximum likelihood with robust indicators in small sample sizes (Nevitt & Hancock, 2001; Yuan & Bentler, 2000).

Results

Descriptive statistics and correlations were first analyzed, followed by the path analyses. Preliminary data screening and cleaning were performed prior to analysis. The analytic assumptions were also examined prior to analysis.

Analytic Assumptions

Assumptions were analyzed to ensure that the data was appropriate for the selected analysis. A sample size of at least 60 is required for maximum likelihood techniques with models of eight or fewer predictors (Tabachnick & Fidell, 2013). With 77 participants, there are approximately 10 participants per predictor within the model, so sample size was small but adequate for this analysis. Six percent of data were missing from early reading and early math assessment times. Missing data were believed to be missing completely at random based upon a non-significant Little's MCAR test ($\propto = .22$). In order to maintain a larger sample size, missing data were estimated using mean substitution. Mean substitution was selected because of the multivariate nature of the analysis, making regression methods more difficult, and the non-normally distributed variables, which may make expectation maximization methods more difficult (Tabachnick & Fidell, 2013).

Normality of variables was assessed by visually examining histograms using IBM SPSS and by calculating standardized skewness and kurtosis. Results are presented in Table 5. The earlyMath and earlyReading data were normally distributed and did not have a standardized skewness or kurtosis greater than 3.75. Skewness and kurtosis were present in the DevMilestones data, which was expected given the nature of the scale. Reflection and logarithmic transformations were attempted but model fit was not improved. As such, variables were not transformed in order to retain original correlations and ease of data interpretation. Bollen-Stein bootstrapping was used instead to correct for non-normal distributions within the path analysis. Linearity was assessed using IBM SPSS scatterplots and best-fit lines for all observed variable combinations. All observed variables appear to be linearly related, if at all.

No univariate or multivariate outliers were detected in the dataset. Univariate outliers were assessed by inspecting z-scores and visually examining IBM SPSS boxplots. Multivariate outliers were assessed using Mahalanobis distances and no distances indicated multivariate outliers (χ^2_5 = 20.52). Visual examination of scatterplots and multivariate plotting supported this statistic.

Descriptive Statistics and Correlations

Descriptive statistics for the development composite, including the five measures that compose the score, the early reading, and the early math assessments are presented in Table 5. The means of the individual development measures suggested that the average student in this sample was classified as "emerging" in the fall of kindergarten and as "incorporating" in the winter, which suggested an average sample. Percentiles for composite scores on the DevMilestones measure subtests were not available at the time the study was conducted, but kindergarten students in the fall are expected to be at the "emerging" level and at the "incorporating" level in the winter (Christ et al., 2015).

Participants in this analysis appeared to have typical fall and spring early reading and early math skills, as compared to the FAST percentile rankings for each assessment, presented in Table 5. However, in the winter, both the mean of the early math and early reading data falls below the at-risk cut-off. The early math scores were slightly below the typical population, at the 40th percentile. The early reading scores were lower than expected at the 20th percentile. Participants in this study, as a whole, may have had lower achievement during the winter benchmark administration than the typical kindergarten class.

Table 6 is the correlation matrix for the development composite, the early reading, and the early math assessments across the three benchmark times. As expected, the fall and winter development composite (r = .74) was strongly correlated. Likewise, the fall, winter, and spring early math scores (r = .73 to .81), as well as the fall, winter, and spring early reading scores (r = .68 to .81) were also strongly correlated. Early reading and early math scores were moderately to strongly correlated with each other (r = .57 to .77), while the development composite was weakly to moderately correlated with both the early academic measures (r = .32 to .55).

Path Analysis

Statistics and fit indices for all attempted path analysis models are presented in Table 7. A baseline model, Model 0, where all parameters were freely modeled was first run to establish model comparisons. Fit indices for the baseline model indicated a poor fit, χ^2 (8, N = 77) = 17.94, $p < .05$, CFI = .98, RMSEA = .13. The initial hypothesized academic model, Model 1, seen in Figure 1, was then run to establish the amount of variance accounted for in springtime early reading and math skills by respective fall and winter skills. The model proposed that spring early reading was influenced directly by winter early reading and indirectly by fall early reading, mediated by winter early reading. Spring early reading was also indirectly influenced by the correlation between fall early reading and early math scores. Early math, in turn, was affected in the same way by fall and winter early math scores and by the correlation between fall academic measures. Early math influenced early reading at each assessment time point. Fit indices suggested a poor model fit, χ^2 (8, N = 77) = 19.10, $p < .01$, CFI = .97, RMSEA = .14. The significant χ^2 value suggested that the proposed model differed from the estimated population model, and that the pathways proposed in this model did not appear to accurately depict the development of these skills across the kindergarten year.

Multiple nested models (i.e., Models 2-4) were examined in an attempt to improve model fit. No parameters from the hypothesized model, Model 1, were set to zero, but rather already restricted parameters were no longer set to zero. In other words, additional pathways were added but the fall to winter pathway remained consistent across all tested models. These adjusted models also resulted in poor fit, as seen in Table 7. Based upon the poor fit, the predictive value of the pathways in the model could not be interpreted. These results suggested that, for the data in this study, fall and winter academic skills did not appear to predict spring early academic skills. Even when direct and indirect effects were modified, no combination of effects for fall and winter academic skills predicted spring academic skills.

The hypothesized development model, Model 5, also seen in Figure 1, was then tested to examine if the added development pathway would improve model fit. The development model further specified that both spring early reading and early math were influenced directly by winter development and indirectly by fall development. The correlations between all of the fall benchmark measures also indirectly effected spring early academic measures. Again, early math predicted early reading in winter and spring. Fit indices again suggested a poor fit, χ^2 (16, N = 77) = 27.69, p < .01, CFI = .98, RMSEA = .11.

Multiple nested models (i.e., Models 6-8) were tested in a similar way to the early academic only path analyses. Fit indices also suggested poor model fit, as seen in Table 7. Based on these results, the addition of the development composite pathway did not increase the predictive value of the model. The direct effect of winter development, and the indirect effect of fall development, as mediated by winter development did not appear to significantly predict spring early reading and math measures.

Part of the poor model fits for these models may be due to the fact that the models specified the winter benchmark testing scores as a mediator between fall and spring scores. As seen in the descriptive analysis, the mean winter early academic scores were lower than would be expected for that time of the year. The presence of the mediating path may have decreased the model fit. By removing the winter time-point, the direct effect pathway between fall and spring achievement could be assessed.

Additional nested path analysis models were tested to examine the potential of a direct fall to spring pathway for early academics and development. The hypothesized early academic model, Model 9, and the hypothesized development model, Model 10, are presented in Figure 2. Statistics and fit indices for the fall to spring path analyses are also presented in Table 7. A fall to spring pathway of early academics, presented in Model 9, resulted in a good model fit, χ^2 (2, N = 77) = 2.40, p = .30, CFI = 1.00, RMSEA = .05. The non-significant χ^2 suggested that the model did not significantly differ from the estimated population model. Chi-squared difference tests further suggested that this model was a significant improvement over the baseline model ($\Delta\chi^2 = 15.54$, $p < .05$).

The addition of fall development on spring early academic measures, tested in Model 10, also resulted in good model fit, χ^2 (2, N = 77) = 1.77, p = .42, CFI = 1.00, RMSEA = .00. Again, χ^2 statistics suggested that the estimated population model and the hypothesized model did not significantly differ. The development model was also a significant improvement in model fit over the baseline model ($\Delta\chi^2 = 16.17$, $p < .05$). As both models resulted in adequate fit, the parameter estimates of both models were further examined.

Parameter Estimates

Parameter estimates for both of the fall to spring path analysis models (i.e., Models 9 and 10) are presented in Table 8. Figure 3 presents the final models with standardized coefficients. Across both models, fall early math was a significant predictor of spring early math (γ = .67 and .73). Fall early reading was a significant predictor of spring early reading, but with only a moderate effect (γ = .43 and .47), due to the presence of a significant pathway predicting spring early reading from spring early math (γ = .46 and .48). Fall development was not a significant predictor of spring early math or spring early reading skills, after controlling for fall early math and reading skills. The amount of variance accounted for in spring early reading ($\Delta R^2 = .01$) and spring early math ($\Delta R^2 = .01$) in the models was unchanged by the addition of the development measure.

Discussion

The purpose of this study was to explore an efficient way to measure school readiness across the kindergarten year. Specifically, it was to investigate which school readiness skills at fall and winter benchmarks best predicted end of year kindergarten academic achievement. The developmental pathways that included winter data resulted in a poor fit. Instead, the best fitting developmental models indicate that academic readiness upon school entry in the fall predicted 72% of reading achievement and 54% of math achievement in kindergarten. Fall readiness in early math and reading were associated (r = .77), which was generally consistent with the result of study one; however, kindergarten achievement was uniquely predicted by fall readiness in the specific content area. The addition of fall development had a very minor contribution, and was not critical to academic success in reading or math.

School Readiness Measurement

The findings of this study inform two areas of school readiness assessment. First, early academic skills alone appear to be the best predictors of later academic skills. Second, direct skill-based and domain specific measures appear to be the best indicators of academic achievement in kindergarten. These observations are discussed in more detail below.

School Readiness Skills. The current study explored how performance on school readiness measures predicted end of kindergarten academic skills. As expected, fall early math skills predict early math skills at the end of kindergarten. Again, as expected, fall early reading skills provide predictive information about early reading skills at the end of kindergarten. Because spring early math also contributed predictive value to spring early reading, in addition to fall early reading, the standardized coefficient for the fall to spring early reading pathway was smaller than that of the pathway between fall and spring early math.

Fall development skills do not appear to add predictive value to spring academic achievement, beyond fall academic skills. When academic readiness skills were accounted for in the model, teacher ratings of student development did not improve on the predictions for end of year academic performance. The inclusion of the developmental pathway did improve the chi-squared value; however, the change in χ^2 was trivial ($\Delta \chi^2 = .63$). Although fit indices improved with the addition of the developmental pathway, because the pathway was non-significant, the presence of the pathway did not add predictive value to end of kindergarten academic achievement. Because the pathway was not significant, it is difficult to determine if the improvement in model fit was significant or an artifact of the sample data. Future research may want to address these questions.

The study does suggest that when attempting to measure school readiness skills that will inform end of kindergarten academic success, it appears that early academic skills alone may be the best set of skills to assess in fall. Observational data of developmental measures can also often be influenced by construct irrelevant characteristics, like ethnicity and socioeconomic status (Alvidrez & Weinstein, 1999). Restricting assessment procedures to direct skill based measures may provide a less biased measure of a student's academic skill set. If early academic skills are the outcome of interest, it does not appear that fall development skills are worth the resources needed to measure these skills in kindergarten.

Assessment Types. The current study also explored the possible predictive utility of direct academic measures and teacher ratings scales. It was of interest to explore whether the addition of teacher ratings scales of general student developmental readiness added value to direct measures of academic skills. Observational assessment methods, and in particular teacher ratings, are common methods of assessment in early childhood (Gestwicki, 2013). Arguments have been made that observational data add value to early childhood assessment, as a wider range of skills can be assessed (Bradbury, 2014). The results of the current study indicate though that the developmental rating scale did not add value to predict end of year performance on the academic measures. While observational methods may have practical benefits, like teachers appreciating the ability to add professional judgment to assessment data, the data may not be adding predictive value to later academic skills (Cabell et al., 2009).

It is important to consider that the current study only examined spring early academic skills. It is possible that teacher-rating scales of development do provide important information for teachers in the classroom beyond their value in predicting early academic outcomes, as the majority of teachers share this information with their student's future teachers (NCES, 1993). Fall development most likely predicts end of kindergarten developmental skills, which can be important for a wide variety of tasks. The development composite may even serve as an indicator of a student's ability to access and participate in the classroom setting (NEGP, 1997). It may provide information about the level of support a student may need to benefit from instruction. For example, a student's physical development may be an indicator of his or her need of support in participating in activities and accessing the educational equipment. A student's approaches to learning or social emotional development may influence the child's ability to remain focused for instruction or remain regulated within the classroom setting. It is possible that a student's developmental level predicts the ease with which a student participates in the classroom, while the student's early academic skills predict a student's later academic achievement.

When considering assessment of school readiness skills, it may be important for teachers to rate a student's developmental level to provide an indication of the student's ability to access the classroom as well as potential supports they may need (NEGP, 1997). In addition, it may be helpful for support staff and other educators to understand the student's developmental level (Casbergue, 2011). However, when considering progress monitoring and intervention of skills across the school year it may be more useful to directly measure early academic skills. More research needs to be conducted to further explore this idea.

School Readiness Implications

School readiness assessment has a tumultuous history, which has, at times, led to inappropriate assessment practices for young children (Frey, 2005; Meisels, 1999). Specifically, students have been at-risk of being delayed in their school entry or retained in kindergarten (Crothers et al., 2010; Raffaele-Mendez et al., 2015). The current study hopes to add to research on school readiness measurement to be able to provide insight into the most appropriate assessment system in an attempt to curb these assessment practices. As such, practical implications, limitations, and future research options are discussed below to provide implications of these results for school readiness assessment.

Practical Implications. Early childhood formative assessment measures that are efficient are more likely to be valid and used within the classroom setting (Gestwiki, 2014; Nelson, 1998). Teachers have limited time in their day and the time they spend on assessment may best be used to measure those areas that best predict later academic skills (Cabell et al., 2009). The results of the current study suggest that the time and resources spent on conducting observations of developmental skills may not add informational value on a student's academic skills beyond direct skill based measurement alone. Focusing this limited time on skills that are not the best predictors of later academic achievement may frustrate teachers, while occupying their time unnecessarily. An ideal formative assessment would reduce the amount of educational time taken to complete it by measuring those skills that are most influential on later academic success (Deno, 1985). The results of this study suggest that the assessments used to predict spring academic achievement could be reduced to a direct measure of early math and early reading.

Focusing assessments on skills that are not the best predictors of later academic success may also limit student's educational opportunities. For example, students with low development scores may be recommended for intervention in those skills when more direct skill based intervention may be more appropriate. Formative assessments should be designed to provide reliable and valid information of a student's progress within the classroom curriculum (Deno, 1985; Gallagher, 1999). Therefore, only those skills that most influence achievement in the classroom curriculum should be assessed for the sake of intervention.

A worst-case scenario would be that students may be delayed in their school entry based upon delayed development skills. Because of the tumultuous history of school readiness assessment, extra care should be taken in assessing the appropriate skills and intervening appropriately (Meisels, 1999). A formative assessment that is used to identify and monitor interventions for later academic success may need to only include direct skill based measures of early academic skills.

That is not to say that assessing developmental skills may not be important for other aspects of student's learning or engagement in a classroom setting. Developmental levels may provide teachers important information about a student's approach to learning, maturity, or access to the environment. Developmental skills appear to be important indicators of children's overall well being (Head Start, 2000). However, it may not be necessary to monitor and implement interventions for the development of these skills from a formative assessment perspective.

Limitations. All results and implications of those results should be examined in light of the limitations in this study. A large limitation of the analysis was the absence of spring developmental measures. The developmental path between fall and spring developmental measures could not be determined from this study. Without this data, the influence of development on end of year developmental milestones and the influence of early academic skills on developmental milestones could not be determined. In the same way, the utility of observational measures for determining end of year development could also not be determined. Although developmental measures do not appear to inform spring early academic measures, it is likely that they inform spring developmental measures. Without this information, the importance of the development measures for impact on the kindergarten year cannot be fully understood.

The poor fit of the initially hypothesized academic path analysis model was another potential limitation of the study. While it is not possible in the scope of this study to investigate the reason for this poor fit, some possibilities are presented. First, it is possible that the finding was sample specific, given that the particular sample data had lower than expected winter data. In the fall and spring, the mean score of the participants was above the at-risk cut-off point. In the winter, the mean was below the cut-off point. Participants may not have attained the level of early academic skills at the expected rates for students across the kindergarten year, which may have affected the predictive pathway in the model. Another potential explanation was that the variables in the model were highly correlated with one another. Specifically, that the fall to spring pathway was so highly correlated, that the winter pathway did not serve as a mediator variable. The data were also hierarchical in nature. Although the ICC suggested that the classes could be collapsed, it is possible that some classrooms received better instruction in academic skills than others, which may have affected the growth of certain participants and the winter pathway.

Because of the poor model fit, the winter benchmark data were removed from the analysis. Although results suggested that the winter data in this sample might not predict spring early academic skills, the variance accounted for in winter to spring data could not be directly calculated. For that reason, a true representation of predictive value of early academic skills across the kindergarten year could not be calculated. Without this information, the utility of the winter benchmark for a formative assessment of school readiness skills was limited. The lack of demographic data also makes it more difficult to generalize the results of this study. Without this information, it is difficult to determine to which population of students these results apply. Future research may address some of these limitations to increase the validity and generalizability of these results.

Future Research Directions. Replication of these results with a larger sample should be attempted to address limitations. In particular, due to the small sample size in this study, replication will be needed to stabilize the path coefficients (Bearden, Sharma, & Teel, 1982). Examining the academic pathway with another sample of students may also help to explain the poor model fit of the initially hypothesized model. Likewise, the influence of winter academic skills on spring academic skills will need to be examined to better understand the best formative assessment system for school readiness skills.

Data on spring developmental skills should also be collected to examine how this data influences relationship within the model. As part of this examination, it may be interesting to look into the differences that comprise development and early academic measures. Assessments related to social and emotional development were highly weighted in the development composite, as were approaches to learning and physical development assessments, which include attention and regulation. It is conceivable that the development composite may be a measure of soft skills, necessary for success in later schooling and life, not often measured by academic tasks (Daniels, 2014; Denham et al., 2012; Denham, Bassett, Zinsser, & Wyatt, 2014; LaParo & Pianta, 2000). It may be interesting, in future research, to examine how these two measures differ and possibly correlate with other academic or soft skill assessments.

Examining the way these early school readiness skills continue to develop into later schooling may also help to support their assertion as school readiness skills. It will be important in later research to examine if those skills important for school readiness continue to predict academic achievement beyond the kindergarten year to ensure that the skills do help prepare students for formal schooling. Monitoring both developmental and academic skills beyond the kindergarten year may also help to illuminate their influence on later skills.

Conclusion

School readiness skills were measured across the kindergarten year to determine which skills best predicted end of kindergarten early academic success. Developmental and early academic pathways across the kindergarten year were not supported. As expected, early academic skills at the start of kindergarten were the best predictors of end of kindergarten early academic skills. Developmental skills at the beginning of kindergarten did not predict end of kindergarten early academic skills above and beyond earlier academic skills. Observational assessments used to measure developmental skills do not appear to provide added predictive information of spring early academic achievement above and beyond direct skill based measures of early academic skills.

Chapter Three References

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Chapter Three Tables

Table 1

Reliability and Validity Statistics of FAST earlyReading Measures

	Reliability			Concurrent Validity
Measure	α [a]	Split-half [a]	Test-Retest [b]	GRADE
Subtests				
Concepts of Print	.75	.76	.42	-
Onset Sounds	.87	.91	.79	.62
Letter Names	.98	.99	.94	.41
Letter Sounds	.98	.99	.92	.53
Word Segmenting	.95	.96	.86	.58
Nonsense Words	.96	.98	.94	.44
Sight Words	.99	.99	.97	.19
Composites				
Kindergarten Fall	-	-	.91	.68
Kindergarten Winter	-	-	.68	.69
Kindergarten Spring	-	-	-	.67

Note. GRADE = Group Reading Assessment and Diagnostic Evaluation.
[a] For timed measures reliability is based upon items that approximately 84% of students completed. [b] Re-test was administered 2-3 weeks later. Composite is based upon fall-to-winter data. Re-test for the composites are based upon data from one benchmark to the next.

Table 2

Reliability and Validity Statistics of FAST earlyMath Measures

Measure	Reliability			Concurrent Validity	
	α [a]	Split-half [a]	Test-Retest [b]	MAP	GMADE
Subtests					
Number Sequence	.76	.87	.80	.61	.54
Match Quantity	.80	.87	.76	.40	.47
Numeral Identification	.97	.98	.85	.43	.51
Decomposing	.80	.83	.68	.46	.44
Composites					
Fall	-	-	.87	.72	.56
Winter	-	-	.87	.71	.56
Spring	-	-	.87	.59	.63

Note. GMADE = Group Mathematics Assessment and Diagnostic Evaluation; MAP = Measures of Academic Progress
[a] For timed measures reliability is based upon items that approximately 84% of students completed. [b] Re-test was administered 2-3 weeks later. Composites are based upon data from one benchmark to the next.

Table 3

Reliability Statistics of FAST DevMilestones Measures

	Reliability	
Measure	α	Test-Retest [a]
Social and Emotional Development	.91	.68
Approaches to Learning	.83	.71
Physical and Motor Development	.73	.58
Creativity and the Arts	.81	.47
Cognitive Development	.88	.77
Language Development	.90	.79

[a] Test-Retest was computed using fall-to-winter data

Table 4

Factor Loadings of the Model used in Study 1 and the Development Model used to Create the Development Composite Score

Indicator	Development		Early Academics		R^2
	Unstandardized (*SE*)	Standardized	Unstandardized (*SE*)	Standardized	
Study 1 Model					
Social and Emotional Development	1.05 (.04)	.95			.91
Approaches to Learning	.96 (.04)	.90			.82
Physical and Motor Development	.94 (.04)	.86			.74
Cognitive Development	.81 (.04)	.76	.03 (.01)	.22	.79
Language Development	.89 (.04)	.74	.05 (.01)	.30	.84
Early Math			1.64 (.12)	.78	.61
Early Reading			.61 (.05)	.97	.95
Development Model					
Social and Emotional Development	1.03 (.04)	.94	-	-	.89
Approaches to Learning	.97 (.04)	.91	-	-	.82
Physical and Motor Development	.94 (.04)	.85	-	-	.72
Cognitive Development	.94 (.04)	.88	-	-	.78
Language Development	1.08 (.04)	.89	-	-	.80

Note. *SE* = Standard Error. All factor loadings were significant, $p < .01$. R^2 = Percent Variance Accounted for by the Model.

Table 5

Descriptive Statistics for the Development Composite and the Eight Measures of School Readiness

Measure	*M (SD)*	Percentile[a]	Minimum	Maximum	Skewness	Kurtosis
Fall Development Composite	11.08 (3.58)	-	.00	18.70	-.80	1.30
Winter Development Composite	14.95 (3.56)	-	1.60	19.70	-1.63	2.70
Fall Social and Emotional	2.17 (.71)	-	.00	3.90	-.19	.90
Winter Social and Emotional	3.23 (.81)	-	.10	4.00	-1.68	3.54
Fall Approaches to Learning	1.98 (.80)	-	.00	4.00	-.29	1.47
Winter Approaches to Learning	2.90 (.72)	-	.20	4.00	-1.50	2.82
Fall Physical and Motor	2.37 (.71)	-	.00	4.00	-1.30	3.01
Winter Physical and Motor	2.88 (.66)	-	.00	4.00	-2.23	5.98
Fall Cognitive	2.16 (.81)	-	.00	3.50	-.48	-.23
Winter Cognitive	2.89 (.81)	-	.10	4.00	-1.56	1.99
Fall Language	2.39 (.90)	-	.00	4.00	-.57	.12
Winter Language	3.04 (.92)	-	.00	4.00	-1.11	1.19
Fall Early Math	36.88 (10.78)	50^{th}	12.00	66.00	-.05	-.30
Winter Early Math	52.08 (13.48)	40^{th}	15.00	81.00	-.16	.03
Spring Early Math	64.88 (12.38)	45^{th}	17.00	82.00	-1.07	1.94
Fall Early Reading	37.08 (5.72)	55^{th}	25.00	55.00	.61	.77
Winter Early Reading	49.55 (8.87)	20^{th}	28.00	69.00	.11	-.32
Spring Early Reading	67.43 (10.13)	50^{th}	38.00	91.00	-.13	.92

Note. N = 77. M = Mean; SD = Standard Deviation. [a] Percentile rankings were not available for DevMilestone subtest composite scores

Table 6

Pearson's Correlation Coefficients for the Eight School Readiness Variables

Measures	1	2	3	4	5	6	7	8
1. Fall Development Composite	-							
2. Fall Early Reading	.50	-						
3. Fall Early Math	.53	.77	-					
4. Winter Development Composite	.74	.43	.44	-				
5. Winter Early Reading	.33	.68	.66	.32	-			
6. Winter Early Math	.49	.66	.79	.48	.70	-		
7. Spring Early Reading	.53	.75	.76	.51	.81	.77	-	
8. Spring Early Math	.46	.57	.73	.55	.60	.81	.75	-

Note. $N = 77$. All coefficients were significant at $p < .01$.

Table 7

Summary of Multiple Path Analysis Models

Models (Model #)	Model *df*	χ^2	χ^2 difference	CFI	RMSEA (90% CI)	ECVI (90% CI)
Baseline Model (0)	8	17.94*	-	.98	.13 (.05-.21)	.97 (.86-1.19)
Academic Models						
Hypothesized Model (1)	8	19.10*	-	.97	.14 (.06-.21)	.59 (.47-.81)
Adjusted Models						
2	4	14.98*	2.96	.97	.19 (.09-.30)	.64 (.54-.85)
3	6	16.95*	.99	.97	.16 (.07-.24)	.62 (.50-.83)
4	6	17.12*	.82	.97	.16 (.07-.25)	.62 (.51-.84)
Development Models						
Hypothesized Model (5)	16	27.69*	9.75	.98	.11 (.03-.16)	.89 (.75-1.14)
Adjusted Models						
6	11	19.96*	2.02	.98	.11 (.01-.18)	.92 (.81-1.14)
7	14	25.89*	7.95	.98	.11 (.04-.17)	.92 (.78-1.16)
8	14	25.59*	7.65	.98	.10 (.03-.17)	.92 (.78-1.16)
Fall Academic Model (9)	2	2.40	15.54*	1.00	.05 (.00-.24)	.24 (.24-.35)
Fall Development Model (10)	2	1.77	16.17*	1.00	.00 (.00-.22)	.37 (.37-.46)

Note. CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; ECVI = Expected Cross-validation Index; CI = Confidence Interval.
*p <.05

Table 8

Path Coefficients for the Path Analysis Models using Fall and Spring Measures

	Fall Academic Model		Fall Development Model	
Variable	Spring Early Reading	Spring Early Math	Spring Early Reading	Spring Early Math
Fall Early Reading	.47* .83 (.13)	-	.43* .76 (.11)	-
Fall Early Math	-	.73* .83 (.09)	-	.67* .77 (.11)
Fall Development	-	-	.10 .29 (.21)	.10 .36 (.32)
Spring Early Math	.48* .39 (.06)	-	.46* .37 (.06)	-
R^2	.71	.53	.72	.54

Note. R^2 = Percent Variance Accounted for by the Model. Standardized path coefficients are presented on top with unstandardized coefficients presented on bottom. Standard error is presented in parenthesis.
**p* <.01.

Chapter Three Figures

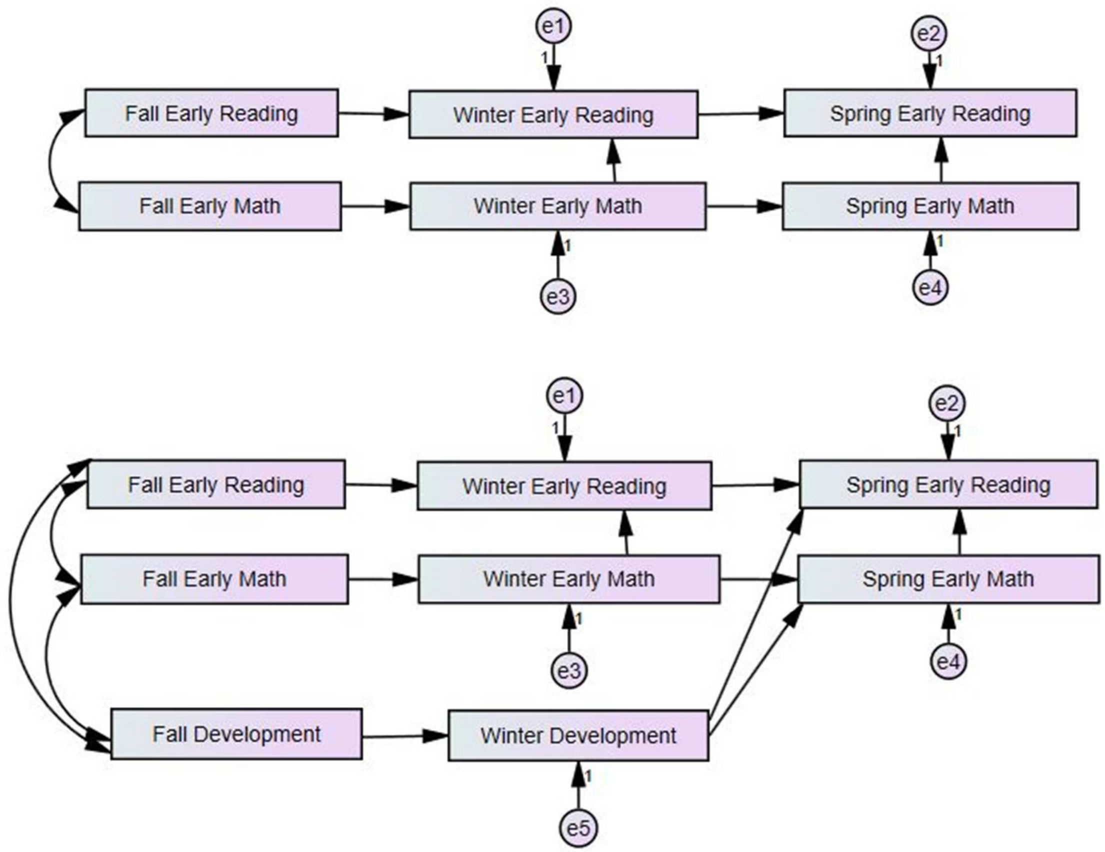

Figure 1. Hypothesized academic path analysis model (top) and hypothesized development path analysis model (bottom). Circles labeled with “e” represent residual error for the observed variables.

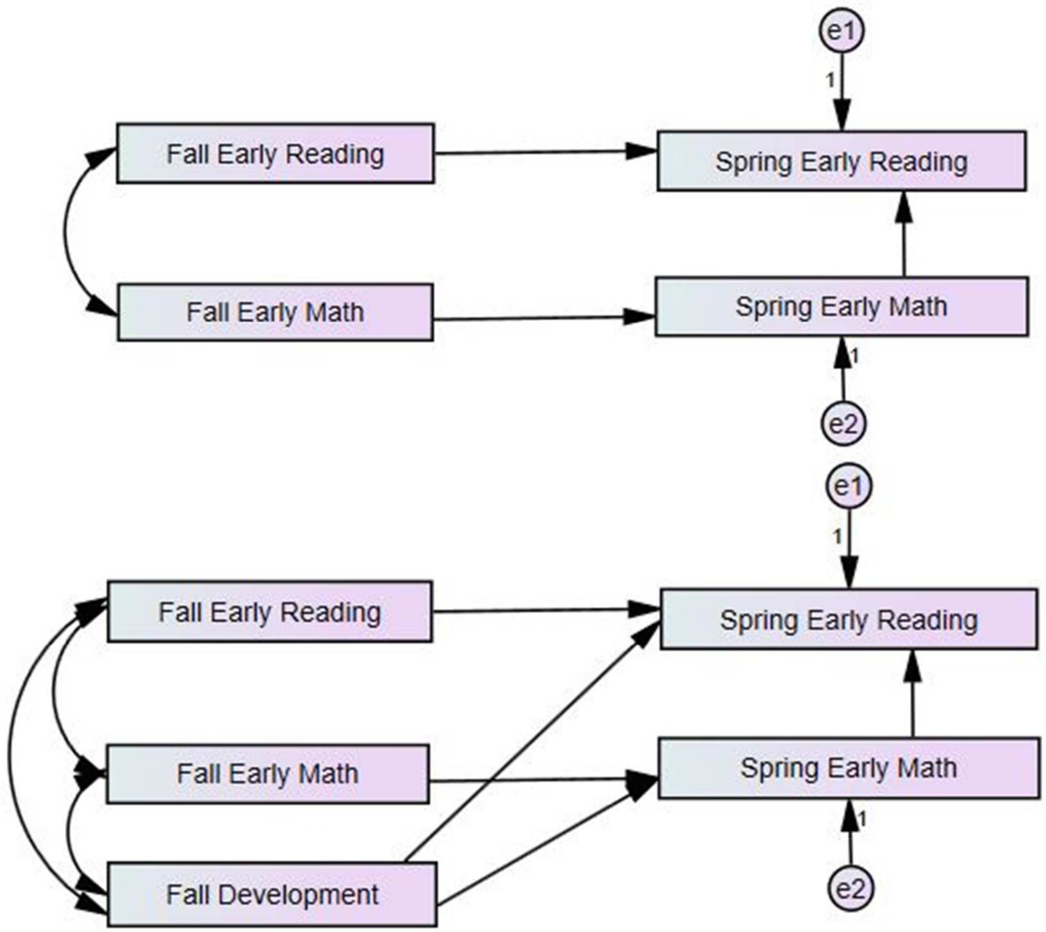

Figure 2. Hypothesized fall academic path analysis model (top) and hypothesized fall development path analysis model (bottom). Circles labeled with "e" represent residual error for the observed variables.

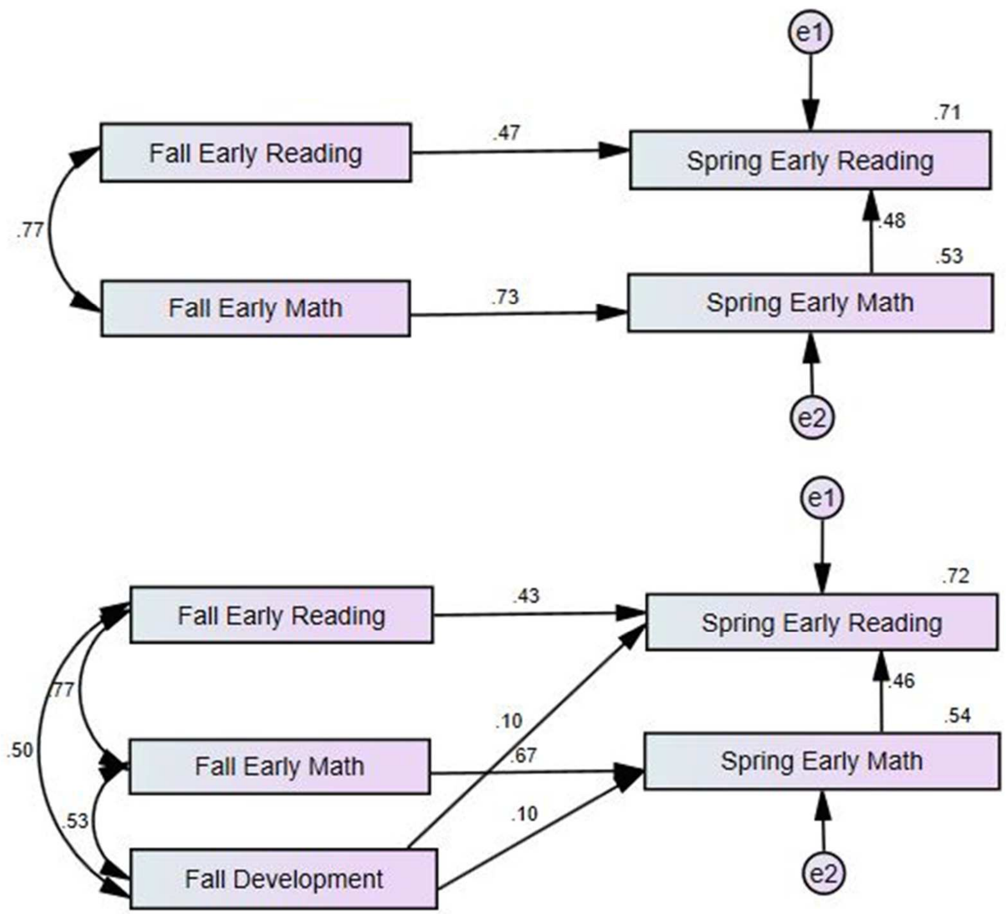

Figure 3. Standardized coefficients for the fall academic model (top) and fall development model (bottom). R^2 values are presented on the upper right of endogenous (outcome) variables.

Chapter Four

Strong school readiness skills are often considered important as they can help students in developing the skill set needed for academic success (Davoudzadeh, McTernan, & Grimm, 2015; Duncan et al., 2007; Hecht, Torgesen, Wagner, & Rashotte, 2001; Hooper, Roberts, Sideris, Burchinal, & Zeisel, 2010; National Association for the Education of Young Children (NAEYC), 2002; Reschly, 2010; Snow, 2006). However, the definition of school readiness skills and how to best measure these skills has often been debated (Daily, Burkhauser, & Halle, 2012; Justice, Bowles, Pence-Turnbull, & Skibbe, 2009; Yoon, 2015). The current dissertation thesis proposed a two-study format to develop a possible definition for school readiness and to examine an appropriate way to measure school readiness skills across the kindergarten year.

Study One

Study one aimed to identify a definition of school readiness and establish a possible way to measure school readiness skills in an efficient manner. In study one, several possible models of school readiness were proposed to identify the factor structure that best fit the school readiness skill measures. The models were nested in terms of restrictiveness and Confirmatory Factor Analysis (CFA) was used to identify the best model. Results suggested that the best model fit was a modified two factor cross loading indicators model.

Two correlated factors best explained school readiness within this model, Early Academics and Development. Measures of early reading, early math, language development and cognitive development loaded onto the Early Academics factor.

Developmental milestone measures, including social and emotional, physical and motor, language, and cognitive development, as well as, approaches to learning were explained by the Development factor. During model modification, the creativity and the arts measure was removed from the analysis to increase model fit. Two indicators, language and cognitive development, loaded onto both factors, but were both better indicators of the Development factor.

Study Two

Study two sought to examine which school readiness skills across the kindergarten year best predicted spring early academic achievement. Fall and winter early reading and math measures and development composite scores were used in the analysis. Development composite scores were based off of the two-factor structure modeled in study one and were comprised of summed scores of the five developmental measures (i.e., approaches to learning, social and emotional, physical, cognitive, and language development) that were indicators of the Development factor. The measures were used in an initial path analysis, which hypothesized that both development and early academic scores in fall and winter would predict spring early academic scores.

The path analysis model for both academic pathways and developmental pathways resulted in poor model fit. In other words, the results suggested that spring early academic achievement, for this sample of students, could not be predicted by the combined direct and indirect effects of fall and winter early academic or development measures. Alternative nested path analysis models were then used to determine which school readiness measures at the beginning of kindergarten predicted end of kindergarten early academic skills. As expected, fall early math skills predicted later early math skills, and fall early reading skills predicted later early reading skills. Spring early math skills also predicted spring early reading skills. Development measures were not a significant predictor of spring early academic skills, after controlling for fall early academic skills.

Integrated Summary

Together the two studies suggested that in the fall of kindergarten, school readiness can be defined by two latent concepts, a student's achievement in developmental milestones and early academics, including early reading and early math. However, the combination of these school readiness skills may not predict end of kindergarten early academic achievement. Instead, early reading and math measures alone appear to be sufficient to predict end of kindergarten academic achievement. The purpose of this study was to focus on academic achievement in the spring of kindergarten. Future research needs to be conducted on whether or not a student's level of development in the fall of kindergarten influences later development or soft skills. The studies further suggested that school readiness for academic achievement may be most efficiently measured in kindergarten with a direct skill based measurement approach.

School Readiness Measurement. Two aspects of school readiness assessment have made it difficult to accurately assess school readiness in the past. First, current definitions of school readiness define the set of skills needed for school readiness broadly, and it has been difficult to ascertain the appropriate skills to assess (Graue, 2006; Snow, 2006). The first study has contributed to school readiness assessment literature by providing a possible model of school readiness and providing combinations of skills that can be assessed to measure school readiness in the fall of kindergarten.

Second, the history of school readiness assessment has resulted in inappropriate assessment procedures (Meisels, 1999; Shepard, 1997). A school readiness assessment that is both developmentally appropriate and increases efficiency in assessment is needed (School Readiness Indicators Initiative, 2005). Study two may help in developing this assessment, as it showcases that early reading and math skills, both direct skill based measures, were the best predictors of later early academic achievement. Fall development, a teacher rating measure, does not appear to add predictive power in spring early academic scores, over fall early academic skills. Teacher observation ratings of student's development may be a time consuming task that is not providing additional information about a student's academic achievement (Cabell, Justice, Zucker, & Kilday, 2009). If early academic achievement is the outcome measure of importance for a particular classroom setting, then assessing early reading and early math measures alone appears to provide sufficient data.

School Readiness Context. In the introduction, the context of school readiness literature was delineated. Those three areas of context are further explored here to examine the possible influence these results may have on school readiness research.

Historical. School readiness assessment has become increasingly more in demand as more children enter early childhood settings and the impact of high quality early intervention has been demonstrated (Peisner-Feinberg, 2004; Pianta, 2007). As demand increases for early childhood education, a measure of readiness for formal schooling has also become more needed. The results of these studies has helped to inform the definition of school readiness and to be able to accurately assess and understand the latent constructs that underlie school readiness. Results have also suggested the most important school readiness skills to predict end of kindergarten academic achievement. These results may serve as an initial starting point in looking at a valid way to assess the development of school readiness skills.

Theoretical. Traditionally, the theoretical approach of school readiness has been one in which students naturally develop the ability to benefit from school (Carlton & Winsler, 1999; Piaget, 1936). In recent years, theory behind school readiness has shifted. School readiness has begun to be looked at from a social learning and ecological viewpoint, where children are supported by educators to develop a skill set early in education that helps them in formal schooling (Bronfenbrenner, 1979; Vygotsky, 1978).

The results of the current research supported a social learning approach to school readiness. It appears that fall early academics were the best predictors of academic success in kindergarten. Academic skills are typically skills that are taught within an educational environment, consistent with a social and ecological framework. Providing a strong educational environment may improve student outcomes in kindergarten. Furthermore, the use of a formative assessment is supported by a social learning approach. By using a formative assessment, data can be obtained to determine students in need of increased instructional support. Teacher support for those students who need intervention in early academic skills may result in higher end of kindergarten academic achievement.

Policy. Policy surrounding school readiness can be complicated as different stakeholders emphasize different aspects of school readiness skills. Policy makers, teachers, and parents often disagree about what skills comprise school readiness and the importance of each type of skill (Belfield & Garcia, 2014; Blair & Raver, 2015; LaParo & Pianta, 2000). States also tend to have different standards and assessments when measuring students' school readiness (Daily et al., 2012). The present results may help to answer some questions about what skills are included in a consistent definition of school readiness and to better understand the concepts that underlie these skills. The two studies also helped to illuminate which skills are important for school readiness and how they differentially impact end of kindergarten academic success.

School Readiness Implications. Implications for each study are discussed in their respective sections. However, integrated implications of the overall results are also briefly discussed here.

Practical Implications. Because the focus of these two studies was largely on statistically modeling school readiness, the validity of any practical implications would need to be supported by further research. Still, the results of these analyses may lay the initial groundwork for defining school readiness and identifying skills that are most important to developing early academic skills across the kindergarten year. These two findings may help in developing an efficient formative assessment of school readiness to include only those measures that provide the most useful data. Having such an assessment may help educators to assess and monitor appropriate school readiness skills, to be able to intervene at needed points in time. The results also suggest that teacher observations may not provide additional information above direct skill based measures and, as such, may not be the best use of limited time and resources when assessing academic success in kindergarten. Furthermore, because the measures used in these studies were developed to be quick on-line assessments, educators may also, in the future, have access to an efficient and developmentally appropriate manner of assessing school readiness skills.

Limitations. Certain limitations occurred across both studies because of the similar data used across studies. Demographic information for participants was missing because teachers within schools filled this information out themselves. The lack of demographic information restricts generalizability of the findings, as the population of the sample was largely unknown. Data in both studies were also hierarchical in nature. Statistical adjustments were used in an attempt to correct for the violation of assumptions. Still, future research should replicate these results with larger sample sizes so possible higher-level effects could be investigated. Finally, the lack of available developmental spring data limited the types of research question that could be answered. Specifically, missing developmental milestone data made it difficult to examine if a student’s developmental level in fall predicts later developmental or soft skills. Without this information, it is difficult to determine if a student’s progress in developmental milestones is important to assess over the kindergarten year. These limitations as well as specific limitations discussed within each study should be addressed in future research.

Future Research Directions. Each study either used or was influenced by latent construct techniques. Therefore, both studies should be replicated to ensure that the sample used in this study was truly representative of the kindergarten student population. Future research could be continued in a number of directions, based upon the results of these studies. First, research could continue to examine the use of formative assessment in school readiness. Specifically, to determine if direct skill based measures remain the best predictors of later academic skills across the kindergarten year. In addition, researchers may want to further develop a school readiness specific formative assessment that would be available to early childhood settings.

Second, more research could investigate how developmental milestones and early academic skills develop over the kindergarten year. Specifically, these studies were not able to address the role that beginning of kindergarten developmental milestones and early academic skills might play on end of kindergarten developmental milestones. In addition, looking forward into early elementary school to see how later academic measures correlate with these school readiness skills may help to further define the relative importance of the different components of school readiness. Also, examining individual differences in these developmental pathways will most likely be needed, as developmental windows are wide in young ages and development occurs rapidly.

Finally, once the development of school readiness has been explored and a formative assessment has been fully developed, it will be helpful to conduct studies to examine the utility of using formative assessments to determine the need for interventions. In the same way, research would also be needed on how well these school readiness measures are able to measure growth and monitor progress over shorter periods of time, in a response to intervention framework.

Conclusion

School readiness appears to be comprised of achievement in developmental milestones and early academic skills. A student's level of development at the beginning of kindergarten does not appear to add predictive value to end of kindergarten academic achievement, above and beyond fall early academic skills. Therefore, teacher observation ratings of developmental skills may not be necessary when direct skill based measurements of early academic skills are available, if assessing academic skills. The results of these studies support a clear definition and possible measurement system for school readiness in kindergarten. Ensuring children are ready for school by efficiently monitoring important school readiness skills may help to prevent later schooling difficulties and bolster student success.

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Appendix A

Items on the FAST DevMilestones assessment, categorized by domain:

Social and Emotional Development

1) Child understands and appreciates his/her uniqueness in one's family, community, culture, and the world.
2) Child demonstrates early emotional awareness and responsiveness.
3) Child recognizes his/her own emotions.
4) Child displays the ability to manage emotions and behaviors.
5) Child displays the ability to manage thoughts and attention.
6) Child displays confidence through experimentation, willingness to make mistakes, and ability to move on.
7) Child demonstrates the ability to establish and sustain relationships with others.

Approaches to Learning

1) Child engages in daily routines and activities across settings.
2) Child demonstrates curiosity and initiative.
3) Child takes academic and intellectual risks.
4) Child exhibits imagination and inventiveness in activity participation and problem solving.
5) Child persists with tasks until they are completed.
6) Child reflects on previous experiences and uses this information to make predictions.

Physical and Motor Development

1) Child demonstrates foundational movement and mobility skills.
2) Child displays gross motor development.
3) Child demonstrates object manipulation skills with increasing sophistication.
4) Child displays fine motor development.
5) Child takes on an early, active role in his/her own health and well-being.
6) Child demonstrates understanding of physical health and well-being; exhibits behaviors consistent with this understanding.

Creativity and the Arts

1) Child demonstrates willingness to use a variety of media and participate in creative expression.
2) Child communicates and shows interest in the creative work of self and others.
3) Child displays opinions and personal preferences regarding art and creative expression.
4) Demonstrates understanding of the different skills and resources needed for various forms of creative expression.

Cognitive Development

1) Child recognizes shapes and compares multiple objects in regards to spatial relationships and measureable characteristics.
2) Demonstrates understanding of patterns and relationships between objects.
3) Child demonstrates understanding of basic number concepts.

4) Effectively uses concrete and abstract strategies to solve mathematical problems.
5) Child demonstrates early exploration and problem solving.
6) Child demonstrates expanding memory and representational skills.
7) Child engages in active problem solving to complete tasks.
8) Child takes a scientific approach to the evaluation and completion of tasks.
9) Child demonstrates appreciation and understanding of human relationships at multiple levels (e.g., classroom, school, family, and community); considers how he/she can help others.
10) Child demonstrates an understanding of the reciprocal relationship between the individual and the environment.

Language, Literacy, and Communication

1) Child demonstrates an early understanding of language.
2) Child follows basic oral directions.
3) Child demonstrates early communication skills.
4) Child uses age-appropriate vocabulary and syntax through verbal (saying words), gestural (signing words), or graphic (pictures or augmented communication) forms of language.
5) Child uses age-appropriate grammar through verbal (saying words), gestural (signing words), or graphic (pictures or augmented communication) forms of language.
6) Child follows agreed upon rules during conversations with others.

7) Child engages in increasingly complex social conversation with others for a variety of purposes.
8) Child demonstrates early literacy skills.
9) Child participates in use of text in various ways to demonstrate early reading skills.
10) Child demonstrates motivation and enthusiasm for reading and literacy activities.