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The Inquiry Game: Assessing Inquiry Skills in Low-Income Preschoolers

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UNIVERSITY OF MIAMI

THE INQUIRY GAME: ASSESSING INQUIRY SKILLS IN LOW-INCOME
PRESCHOOLERS

By

Irene Nayfeld

A THESIS

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Master of Science

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THE INQUIRY GAME: ASSESSING INQUIRY SKILLS IN LOW-INCOME
PRESCHOOLERS

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Inquiry skills in young low-income children may be an important point of intervention for promoting school readiness and later academic achievement. The current study aimed to investigate and measure the inquiry skills of low-income preschoolers. In a newly-designed, game-based assessment (the Inquiry Game), children were instructed to ask questions to determine a target picture among an array of pictures varying by color and object type. Asking constraint-seeking questions that use color and object type to eliminate multiple pictures is a more efficient strategy (and thus evidence of greater inquiry skills), in comparison to asking about a specific picture. One hundred and sixty Head Start preschoolers' inquiry skills were assessed using the Inquiry Game at three time points. Data on children's problem solving, *math, language, and literacy skills* were also collected to examine concurrent and predictive validity of the measure. Results revealed that asking about one picture at a time was the most popular strategy at all time points; however, children asked more efficient questions in the winter and spring when compared to performance in the fall. Analyses revealed a relationship between inquiry skills and vocabulary, verbal reasoning, and matrix reasoning ability. Results, as well as future directions, are presented and discussed.

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Chapter 1: Introduction

An achievement gap is consistently found between low-income children and their middle- to high-income peers in academic performance, language development, and analytical reasoning skills (Hart & Risley, 1995; Lareau, 2003; Walker, Greenwood, Hart, & Carta, 1994; Weatherholt, Harris, Burns & Clement, 2006). These differences are present by the time a child begins formal education (Magnuson & Duncan, 2006; Neuman & Celano, 2006) and continue through later grades (National Assessment of Educational Process [NAEP], 2009). In fact, socioeconomic status in early childhood has been found to be predictive of educational attainment even into young adulthood (Entwisle, Alexander, & Olsen, 2005). In order to lessen this gap, efforts must be made to identify skills that significantly affect early academic achievement and to develop methods for improving these skills in at-risk children.

One skill set that facilitates academic success is active engagement and participation in learning opportunities. Research conducted on school readiness and academic achievement has indicated that children who are actively engaged in the classroom achieve more academically than those who are less actively engaged (Connell, Halpern-Felsher, Clifford, Crichlow, & Usinger, 1995; Skinner & Belmont, 1993; Tucker et al., 2002). Behavioral engagement in school is defined as involvement in learning and other academic tasks and is characterized by behaviors such as effort, attention, persistence and question-asking (Fredricks, Blumenfeld, & Paris, 2004). Cross-sectional studies have consistently found that these behaviors are correlated with better academic outcomes in children across various ages (Marks, 2000; Skinner & Belmont, 1993; Skinner, Kindermann, Connell, & Wellborn, 2009). One longitudinal study demonstrated

that children who were more engaged in first grade had lower drop-out rates and higher academic success in high school (Alexander, Entwisle, & Kabbani, 2001).

The ability to ask questions is a central component of engagement in the classroom. Question-asking relates to children's capacity to acquire new knowledge, participate in classroom activities, and the quality of their interaction with teachers. Question-asking, or inquiry, in young low-income children is therefore an important area of study. The current study investigates young children's ability to ask efficient questions in order to solve a problem. Children's performance on a newly created measure of inquiry, the change of this performance over the course of the school year, and its relationship to academic outcomes is examined in order to broaden understanding of inquiry skills in this understudied population.

Inquiry and Engagement in the Classroom

Asking questions is a domain-general skill that lays a foundation for overall learning and achievement (Berland & McNeill, 2009; Gopnik, 1998; King, 1994; Martinello, 1998). Questioning or inquiry allows the individual to identify areas in one's cognitive schemas that lack clarity and obtain new information to develop more accurate representations and more sophisticated reasoning (Chouinard, 2007; Gopnik, 1998; Palincsar & Brown, 1984). The National Science Education Standards (1996) state that "inquiry is central to science learning" and urge teachers to encourage question-asking in all fields of knowledge, and in learners of all ages. Correspondingly, teaching through inquiry has been shown to benefit students across ages and topic areas (Chin & Osborne, 2010; Klahr, 2000). In addition, high-achieving students have been found to engage in

question asking more frequently than their classmates (Blank & Covington, 1965; Newman, 1998).

An integral part of being an active and engaged learner is asking questions in the classroom. Asking questions is a key part of engagement and a tool for demonstrating and measuring involvement and interest in the material (Fredricks et al., 2004).

Teachers' perception of a child's engagement also predicts his or her interactions with the child across the school year (Skinner & Belmont, 1993). A child who is engaged in the classroom tends to receive more attention, positive response, and support from a teacher than a child who does not. Receiving this positive feedback in turn increases the child's involvement, creating a cascade of positive effects (Marks 2000; Skinner & Belmont, 1993).

Studies using middle-income samples have found that young children are capable of asking questions to acquire information and use that information to solve a problem (Chouinard, 2007; Courage, 1989; Denney & Connors, 1974; Rule, 2007). However, more research is needed to explore whether these findings can be generalized to diverse, low-income populations. Further, previous work has not examined how children's performance on these inquiry measures correlates with and is predictive of their abilities in other academic areas. The purpose of the proposed project was to develop and validate a measure of inquiry skills in low-income children. Data on preschoolers' inquiry skills were collected using a newly-designed direct assessment, the "Inquiry Game." Skills believed to be related to inquiry, including reasoning ability and school readiness, were assessed in order to examine convergent and predictive validity of this new assessment.

Theoretical Considerations of Inquiry in Cognitive Development

The constructivist theory proposed by Piaget describes the child as a constant explorer who is actively engaged in seeking knowledge and reorganizing existing cognitive representations, or mental schemas, based on this exploration (Piaget & Inhelder, 1969). According to Piaget, the child assimilates new information into existing schema. The child seeks new information that is moderately novel from the familiar information already in the schema. This produces disequilibrium in the schema resulting from the inconsistencies between information that is already known and new information that is only partially understood (Piaget, 1953). In order to restore equilibrium, the child strives to resolve these inconsistencies. (Piaget, 1983). This basic process requires the child to form and pose questions about a partially unknown concept and in turn seek answers to these questions.

While Piaget believed that autonomous exploration is key in the process of seeking cognitive equilibrium, other theorist have focused on adult-guided learning as an additional fundamental part of the process of cognitive development. Vygotsky (1978) argued that children learn through interaction with more knowledgeable individuals. He emphasized the role that these individuals play in the development of knowledge and the scaffolding process that takes place as children are aided in their explorations. As children form new ideas about objects and phenomena around them, the guidance of an expert, such as a parent or teacher, helps them understand the new information. This process is necessarily guided by inquiry. Asking questions draws attention to areas of cognitive disequilibrium and affords an opportunity to gain information that may have

otherwise remained undiscovered. Questions also provide a cue to more knowledgeable individuals that more scaffolding is needed, leading to increased learning.

Extending Piaget's and Vygotsky's thinking, cognitive psychologists have proposed that children are propelled to seek answers to their own questions. For example, Gopnik (1998) posits that children are born with a "theory drive" that propels them to seek explanations. According to this theory, young children, as well as scientists, have an active theory-formation system that seeks to uncover the cause of observed phenomena. According to Ram's question-driven learning theory (1991), "question generation" occurs when the learner identifies what he or she needs to learn. Inquiry identifies awareness of a lack of understanding and seeks to close that gap. In turn, understanding occurs as questions are answered. Children engage in autonomous exploration, build their own theories and narratives, and ask many questions to aid in their quest to resolve cognitive disequilibrium.

Benefits of Effective Inquiry

Understanding question generation can help alert adults to a child's cognitive state and inform teaching theory and practice. Children's questions reflect not only their lack of understanding but also their area of interest and the knowledge that they need to advance learning (Ram, 1991). The process of identifying gaps in one's knowledge and using inquiry to draw attention to those gaps helps achieve better understanding and gain the child access to more complex cognitive schemas across all domains of learning.

Questioning functions as a check for current understanding and a strategy to gather new information (Palincsar & Brown, 1984). A series of studies by Chouinard (2007) investigated the role that asking questions plays in the process of cognitive

development. According to these studies, active engagement and questioning by the child results in better learning, understanding, and recall. By using questions and revising their ideas based on the answers, children achieve a better long-term understanding of the world around them. These studies demonstrated that children as young as two can and do ask questions, and that when the question is not responded to, children persist until an adequate answer is given. Further, preschool children use information given by adults to structure their knowledge and apply it to solve problems.

Inquiry has been defined as having several components and comprising a cyclical, scientific method of investigation (Klahr, 2000; Kuhn & Pease, 2008). Within this broader context, the proposed study focused on the questioning and inquiry strategies used to arrive at a solution to a posed problem and the efficiency of the strategy used. Although previous research demonstrates that asking questions is a critical skill that aids in the development of reasoning, there is a lack of reliable and valid measures of this ability in young children. In particular, questioning skills have not been investigated in low-income preschool children. A necessary first step in conducting such investigations is the availability of instruments that validly assesses questioning skills in young, low-income children. The current study contributes to this literature by developing a measure to examine inquiry skills in low-income preschoolers.

Measurement of Inquiry Skills

Several studies investigating young children's inquiry skills have used the game "Twenty Questions," in which the assessor thinks of a specific object and the child is told to ask questions in order to guess which object the assessor is thinking of (Courage, 1989; Denney & Connors, 1974; Mosher and Hornsby, 1966; Thornton, 1999). Using this

game, Mosher and Hornsby (1966) found children's inquiry skills—or the efficiency with which they ask questions to solve the problem—increases with age. The authors categorized the types of possible questions into two categories: constraint-seeking (CS) and hypothesis-seeking (HS). CS questions are those questions that ask about a category of items (e.g., *“Is it something green?”* or *“Is it an animal?”*), thereby constraining the possible solution to only one group, or eliminating a group of items at once. These types of questions result in a more efficient solution to the game and, thus, demonstrate a higher level of inquiry ability. HS questions ask about one specific item at a time (e.g., *“Is it that turtle?”*), making it a less efficient strategy than CS questioning. Mosher and Hornsby found that while only 2% of the questions asked by 6 year olds were CS questions, this number increased to 83% when the task was done with 11 year olds.

One potential reason for this difference is young children's inability to categorize and induce relationships from perceptually available information. However, research suggests that this is not the case. Children as young as 2.5 years of age are able to categorize objects based on perceptual categories such as shape and color (Piaget & Inhelder, 1964). They are also able to override perceptually salient categories to group objects by non-visible categories, such as their biological properties, function, and relationship to other objects (Deak & Bauer, 1996; Gopnik & Sobel, 2000; Massey & Gelman, 1988).

Manipulations of the Twenty Questions task have revealed that young children possess the ability to use categorical information for reasoning and inquiry when this strategy is appropriately modeled. Briefly modeling constraint-seeking strategies to six year olds resulted in an increase of CS questions (Denney, Denney, & Ziobrowsky, 1973;

Johnson, Gutkin, & Plake, 1991). While four and five year olds do not ask many constraint-seeking questions initially, a brief training in which the investigator modeled asking CS questions significantly increased their use of this type of questioning and decreased guessing (Courage, 1989; Denney & Connors, 1974; Thornton, 1999). Courage (1989) performed a brief training with an experimental group in which categorical, or CS, questions were modeled by the experimenter and found that while the control and experimental group were comparable on pretest, the experimental group asked significantly more CS questions during immediate, as well as delayed, posttests. Another study that employed an experimental trial which drew children's attention to the perceptual categories during the game of Twenty Questions found that children in that trial asked more CS questions on posttest than their peers in the control condition (Nelson & Earl, 1973). According to the authors, these results indicate that children have the ability to use categorical-based reasoning but simply do not do so spontaneously. A further examination into modeling techniques found that providing an explanation of cognitive strategy is more effective than exemplary modeling alone for younger as well as older children (Johnson et al., 1991).

Game-based assessments using slightly different techniques have also found that young children are indeed capable of asking categorical, or CS, questions to solve a problem. A classroom activity in which children were presented with a "magic box" and told to ask questions about its contents also found that children as young as four were able to ask categorical questions after the teacher gave examples to demonstrate the strategy (Rule, 2007). In another study, 67 middle-income four- and five-year-olds were asked to play a guessing game in which the child was prompted to ask questions about

form and function in order to guess which of two presented objects was hidden in a box. Children successfully asked questions that allowed them to distinguish between the two objects (Chouinard, 2007). After a brief demonstration trial in which the child hides the toy and the assessor guesses, the children in the experimental condition were told that they could ask questions to guess which object was in the box. The control group was just instructed to guess which object was hidden. Children in the experimental group were able to generate appropriate questions to help solve the problem and were more successful in correctly identifying the hidden object than the group not prompted to ask questions. The studies described above demonstrate that the preschool years are a time when inquiry skills are developing; however, these assessments have not been evaluated in low-income children. To this purpose, Chouinard's (2007) task was modified slightly and used in a sample of 200 Head Start preschoolers (Nayfeld, Fuccillo & Greenfield, 2010). In contrast to the middle-income sample, very few low-income children were able to ask CS questions. In this sample, 24% of the children could not complete the demonstration trial and of those who did complete the demonstration trial, 78% asked no constraint-seeking questions. However, asking at least one constraining question correlated with vocabulary ($r = .25, p < .01$), science ($r = .36, p < .01$), math ($r = .31, p < .01$) and executive functioning ($r = .20, p < .01$). While these correlations indicated that the modified version of Chouinard's task measures a skill related to other areas of school readiness, the low percentage of children able to perform the task indicated that this measure may not be appropriate for low-income preschoolers. In response, substantial changes to the design of the measure were made and the "Inquiry Game" as described below was developed and pilot tested.

The Inquiry Game

In order to address the need for appropriate measurement of inquiry skills for low-income children, an interactive assessment was designed and modeled after the “20 Questions” game, in which children are asked to identify a target item the assessor has chosen. However, several adjustments were made to make this game appropriate for preschoolers and to facilitate measurement of inquiry skills. In the “Inquiry Game”, all possible items are visually available to the child. To reduce the cognitive demand of the child taking on the perspective of the assessor, the child is told that one picture is a “magic picture” and that he or she should ask questions to figure out which picture, in an array of pictures varying by color and object type, is the magic one.

The Inquiry Game consists of three arrays, or items. Each array contains 16 pictures, which are organized into four rows and four columns by two category types: color and object (see Figure 1). The colors used are red, blue, green, and yellow. The objects include a car, a bird, a flower, and a house. Consequently, children can use the categories of color or of object type to ask CS questions and eliminate more than one object at a time. For example, a child can ask “Is the magic picture a car?” which would eliminate all cars, or “Is the magic picture yellow?” which would eliminate all yellow objects. Children can also ask HS questions by asking about a specific picture. For example, a child can ask “Is the magic one the blue house?” or “Is the magic one the red bird?” These questions would only eliminate the specific picture in question.

To ensure that only CS questions are rewarded, the assessor does not actually pick a magic picture beforehand (so that guessing a specific item early in the game does not accidentally encourage HS questioning). Instead, the magic picture is always the last

picture that remains after the child has eliminated all other options. For example, if the child asks “Is the magic picture blue?” the assessor always answers “No, the magic picture is not blue, but now we can cover up all the blue ones.” When only two pictures are left, whichever picture the child asks about is said to be the magic one by the assessor. Consequently, asking CS questions results in a more efficient strategy by allowing the child to arrive at the right answer by asking fewer questions.

To further ensure that the measure is appropriate and understood by the participants, easily identifiable colors and objects were chosen. Children are given a screener before they begin the game in which they are asked to name each object and color that will be used in the assessment. They are then presented with eight colored objects from the assessment (e.g., a green car, a blue bird, etc.), asked to point to the specific item named by the instructor (e.g., “Please point to the red flower”), and then asked to verbally identify four of the items chosen by the assessor by their color and object type (e.g., “This is a green car.”) If a child is not able to complete this screener, they are not administered the measure.

If the child passes the screener, he or she is instructed that they will play a game in which they have to act as a “detective” and ask questions to figure out which picture is a magic picture in the display. In response to research indicating that a brief explanation of the game and strategy increases performance (Courage, 1989; Denney et al., 1974; Johnson et al., 1991), inquiry strategies are modeled prior to assessment. Children are introduced to a puppet named “Iggy” who first plays the game with the assessor using a similar array of pictures but with different colors and objects. The assessor asks both hypothesis-seeking and constraint-seeking questions to find the target picture. The

puppet answers “no” to all questions, thus eliminating one or more pictures with each question. As pictures are eliminated, the assessor covers them up using pieces of paper, using a small piece of paper to cover a single picture and a bigger piece of paper to cover several items at once. This provides a visual cue of the elimination of pictures and also decreases demands on working memory to remember which pictures have been eliminated. CS questions are verbally encouraged by the assessor by pointing out that the questions that allow you to cover up “lots of pictures at once” are “very good” questions.

The number of questions the child asks in order to arrive at the target picture is recorded, and this is repeated for the three items, or arrays; the total number of questions asked by the child is considered the score for the measure. As constraint-seeking questions that used color or object type to eliminate answers are more efficient than HS questions asking about a specific item, higher inquiry ability is operationalized as asking fewer questions to arrive at the solution. The number of possible questions range from 6 to 15 for each item. (A score of 16 or higher would indicate that the child asked one or more questions that did not provide any new information, such as repeating a question about a picture or asking a constraint-seeking question when only one category remains.) The most efficient strategy results in 6 total questions and guessing about each specific picture results in 15 questions. When the questions from all three items are summed, total possible raw scores range from 18 to 45.

Pilot Testing

The “Inquiry Game” was piloted with 67 Head Start preschoolers in the spring of 2010. Six children did not pass the screener, and two did not complete the assessment due to disengagement. Of the students who passed the screener and completed the

measure, 59.3% percent did not ask any constraint-seeking questions. Of the 40.7% who asked at least one constraining question, there was an even distribution of the number of questions asked, with an average of 11 questions per item. These preliminary results indicated that this measure is more appropriate for this population of preschoolers, as 91% of children were able to pass the screener and participate in the game. Further, the distribution in performance signifies that the design of this measure is able to discriminate among varying levels of inquiry skills.

Current Study

The current study investigated the validity of the Inquiry Game in measuring the inquiry skills of Head Start preschoolers. Data were collected to examine the concurrent and predictive validity of the measure. Construct validity, which includes identification of the content domain, cognitive processes being tested, and appropriateness of the measure (Miller & Linn, 2000), was established by a thorough literature review, pilot testing, and further data collection and analysis. Concurrent validity, which is indicated by the correlation between the measure and a contemporaneous criterion (Osterlind, 2006), was examined using a measure of reasoning and problem solving in the fall of 2010. Predictive validity, which establishes a relationship between the measure and a criterion measured at a later time (Osterlind, 2006), was examined using the Learning Express in the winter and spring of 2011, which measures children's math, literacy, and language skills. The hypotheses of the current study were as follows:

1. It was predicted that the majority of preschoolers would only ask hypothesis-seeking questions. Among those that ask at least one constraint-seeking question, the number of questions asked was expected to be normally

distributed. This was based on previous work indicating that middle-income children of this age rarely engage in spontaneous CS questioning (Courage 1989, Denney et al., 1984, Johnson et al., 1991) as well as pilot testing confirming this in a low-income population.

2. It was hypothesized that children's inquiry skills would positively correlate with their scores in mathematics, vocabulary, alphabet knowledge, and listening comprehension, as well as reasoning and problem-solving. This was hypothesized because inquiry involves mechanisms necessary for other school readiness domains. Optimal performance on the task requires the child to attend to category membership, use that categorical information, and constrain a larger set to reach the solution (Johnson et al., 1991; Markovits, Schleifer, & Fortier, 1989; Nelson & Earl, 1973), which are techniques also utilized in problem-solving tasks.
3. It was hypothesized that inquiry skills would predict growth in mathematics, vocabulary, alphabet knowledge, and listening comprehension. This hypothesis was based on previous work suggesting that the ability to ask questions is a domain general skill that can increase learning and overall academic achievement (King, 1994; Martinello, 1998).

Chapter 2: Method

Participants

Children from five Head Start centers in a large Head Start Program in the southeastern United States were randomly selected. Extant literature suggests the cognitive demands of similar tasks may not be developmentally appropriate for 3 year-olds (Denney & Connors, 1974; Mosher and Hornsby, 1966), therefore, only children 4 years or older were assessed. Participants were stratified by gender. The Inquiry Game was only administered to children who passed the initial screener that asked children to identify colors and objects used in the assessment. One hundred and eighty children were assessed in the fall of 2010. Approximately half of the children were female (52.5%). Children in the sample were predominantly Black or African American (95.6%), with a small percentage of Hispanic children (4.4%). Out of this sample, 169 children were assessed in the winter, and 171 were assessed in the spring. Children who were not assessed due to repeated absenteeism or withdrawal from the program did not significantly differ in age, gender, or ethnicity from the larger sample at either time point. The average age of children at the beginning of the school year was 55.67 months ($SD = 4.39$).

Measures

Inquiry. Inquiry was measured using the newly-designed Inquiry Game. For each of the three items, children were presented with an array of 16 pictures varying by color (4) and object type (4). Children were instructed to ask questions to figure out which picture is a magic picture, with the magic one always being the last picture left.

The total number of questions asked during the course of the three items functions as the raw score for the assessment.

Reasoning and problem solving. The Wechsler Preschool and Primary Scale of Intelligence™-Third Edition (WPPSI™-III) is a reliable and valid measure of reasoning and problem solving for young children (Gordon, 2004; Wechsler, 2002). Three subscales of the measure were used: (a) Matrix Reasoning - The child selects the missing piece of an incomplete matrix from four or five options; (b) Word Reasoning - The child identifies the common concept described using clues given by the assessor; and (c) Similarities - The child is read a sentence containing two concepts that share a common characteristic and is asked to identify the shared characteristic. Raw scores are scaled by age for each subscale. Possible scaled scores range from 1 to 19 on all three subscales. The scaled scores are based on a sample representative of the U.S. population; it has been previously used in cognitive assessments of children in poverty (Burchinal, Campbell, Bryant, Wasik, & Ramey, 1997). Average reliability of the WPPSI-III is reported to be .96, with reliability for subtests ranging from .83 to .96. Inter-rater reliability ranges from .97 to .99 across subtests (Gordon, 2004).

School readiness. The Learning Express (McDermott, Fantuzzo, Angelo, Waterman, Warley, Gadsden, & Zhang, 2009) is a validated Item-Response-Theory (IRT)-based, criterion-referenced school readiness assessment designed to detect growth in cognitive competencies in the Head Start population. The test is comprised of four subscales: Vocabulary, Mathematics, Listening Comprehension, and Alphabet Knowledge. Each scale has two forms (A and B), allowing for valid retesting. Reliability across subscales ranges from .93 to .98. External and predictive validity was

established for all subscales (McDermott et al., 2009). Children's responses were standardized, and final scores were tabulated based on IRT parameters. The scores were standardized on a metric with a mean of 200 and a standard deviation of 50.

Procedure

Data collection. Data were collected during the 2010-2011 school year as part of a larger data collection. Consent was acquired from teachers who agreed to participate in the larger project. Children were assessed in the fall of 2010 on the three subtests of the WPPSI-III: matrix reasoning, word reasoning, and similarities. Children were assessed on the Inquiry Game, as well as the four subscales of the Learning Express (mathematics, listening comprehension, alphabet knowledge, and vocabulary) in the fall, winter, and spring of the school year. The Inquiry Game, the WPPSI-III, and the Learning Express were administered on separate days. Each session lasted approximately 20-30 minutes.

Validation process. Researchers have identified several accepted sources for and techniques of establishing evidence of validity (Miller & Linn, 2000; Osterlind, 2006). As part of the construct validation of the Inquiry Game assessment, a thorough literature review was conducted to identify the content domain being assessed and to understand the cognitive processes required by the task. Previous measurement designs and pilot testing informed the construction of the measure to ensure appropriate level of cognitive complexity.

To investigate concurrent validity, fall scores on the Inquiry Game were correlated with fall performance on: 1) the four subscales of school readiness as measured by the Learning Express and 2) three subscales of the *Wechsler Preschool and Primary Scale of Intelligence™-Third Edition (WPPSI™-III)* that assess child reasoning

and problem solving. Winter and spring scores on the Inquiry Game were correlated with scores on the Learning Express subscales at the respective time points.

To investigate predictive validity, school readiness data was collected at three times throughout the 2010-2011 school year using the Learning Express, and fall performance on the Inquiry Game was used to predict baseline scores and rates of growth in mathematics, vocabulary, listening comprehension, and alphabet knowledge.

Data Analytic Plan

Item analysis. Overall performance on the Inquiry Game data was examined to assess Head Start preschooler's inquiry skills. Frequency of CS questions and total number of questions asked were calculated, and the distributions were plotted. These statistics were compared across age and sex. Chronbach's alpha was calculated to determine inter-item reliability.

Concurrent validity. Correlations between scores on the Inquiry Game and the WPPSI-III were examined. Correlations between Inquiry Game scores and vocabulary, mathematics, listening comprehension, and alphabet knowledge scores, as measured by the Learning Express in fall, winter, and spring of the 2010-2011 school year, were also be examined. Linear regressions were run in order to examine the relationships of inquiry with school readiness and reasoning when age and sex are entered as covariates.

Predictive validity. A series of latent growth curve (LGC) models were analyzed using MPlus, Version 6 (Muthen & Muthen, 2010) in order to examine the ability of the Inquiry Game to predict baseline scores (intercept) and rates of change (slope) in school readiness as measured by the Learning Express. LGC is an advanced structural equation modeling (SEM) technique that considers change over time as a latent

process and provides several ways to flexibly model change and to capture individual differences in change over time (Kline, 2005). SEM allows for variables to be included as predictors of the intercept and slope and for missing data to be handled using full-information maximum likelihood (FIML) (Muthen & Muthen, 2010). FIML allows for the utilization of all available data in estimation of parameters and has been recommended as the best method for handling missing data in developmental research (McCartney, Burchinal, & Bub, 2006).

Data from the three time points of the Learning Express comprised the latent variables of the intercept and slope. Separate models were analyzed for the four subscales of the Learning Express: mathematics, vocabulary, alphabet knowledge, and listening comprehension. Inquiry skills were tested as a predictor of both the intercept and the slope (See Figure 2). Demographic variables such as age and gender were controlled for in the analyses. A series of indices were used to assess model fit. First, the χ^2 test of model fit was used to assess the fit of the overall model to the data; lack of significance ($p < .05$) indicates acceptable model fit (Kline, 2005). Second, the Bentler comparative fit index (CFI) was examined; values for CFI greater than .90 are considered acceptable (Bentler, 1990; Browne & Cudeck, 1992). Third, the root mean square error of approximation (RMSEA) was examined; values for the RMSEA below .08 are considered adequate (Browne & Cudeck, 1992; Steiger & Lind, 1980).

Chapter 3: Results

Descriptive Analyses

The number of questions asked during the Inquiry Game for each of the three items was summed to derive a single total raw score. A lower number indicates that a child asked more constraint-seeking questions and thus less questions overall, implying a higher level of inquiry skill. A score was derived in this manner at each of the three time points: fall of 2010, winter of 2011, and spring of 2011. See Table 1 for descriptive statistics of scores on all measures.

Inquiry Game data for each time point were analyzed (see Table 2). In the fall, 87.3% of children passed the screener and completed the Inquiry Game assessment. Cronbach's alpha of .73 indicated adequate inter-item reliability. The raw scores ranged from 18 to 47, with a mean of 37.22 ($SD = 8.25$) questions asked. For ease of interpretation, raw scores were converted to z-scores. Z-scores ranged from -2.26 to 1.15. Thirty seven percent of children used only the hypothesis-seeking strategy, asking no constraint-seeking questions. Eight (7.6) percent used predominantly constraint-seeking questions for each item, demonstrating proficient use of the most efficient inquiry strategy. Of children who asked at least one constraint-seeking question, total number of questions asked was evenly distributed, indicating a range of inquiry abilities. See Figure 3 for a graph of the z-score distribution.

In the winter, 94.67% of children passed the screener and completed the Inquiry Game assessment. Cronbach's alpha of .81 indicated adequate inter-item reliability. The raw scores ranged from 18 to 45 total questions, with a mean of 34.84 ($SD = 9.89$) questions. Z-scores ranged from -1.82 to 1.11. Thirty (30.4) percent of children used

only the hypothesis-seeking strategy, asking no constraint-seeking questions. Twenty (20.0) percent used predominantly constraint-seeking questions for each item, demonstrating proficient use of the most efficient inquiry strategy. See Figure 4 for a graph of the z-score distribution.

In the spring, 95.9% of children passed the screener and completed the Inquiry Game assessment. Cronbach's alpha of .88 indicated good inter-item reliability. The raw scores ranged from 18 to 45 total questions, with a mean of 34.06 ($SD = 10.04$) questions. Z-scores ranged from -1.60 to 1.091. Thirty four (34.8) percent of children used only the hypothesis-seeking strategy, asking no constraint-seeking questions. Twenty one (20.7) percent of children used predominantly constraint-seeking questions for each item, demonstrating proficient use of the most efficient inquiry strategy. See Figure 5 for a graph of the z-score distribution.

A series of paired-sample t-tests revealed the total number of questions asked decreased significantly from fall to spring $t(148) = 3.65, p < .01$. There was a significant decrease from fall to winter $t(146) = 3.75, p < .01$. The change from winter to spring was not significant $t(156) = -.051, p = .959$. This decrease in the total number of questions indicates that children's reliance on CS questions, and thus their inquiry skills, improved over the course of the year, with most of the change occurring between the fall and winter time points.

Bivariate Correlations

Correlations between the Inquiry Game and the four subscales of the Learning Express were examined at all three time points. The only significant correlation that emerged was a negative correlation between Vocabulary scores in the fall and Inquiry

Game scores in the spring ($r = -.158, p = .043$), indicating that children who had higher vocabulary scores in the fall asked less questions (and therefore had higher inquiry skills) in the spring.

Correlations between the Inquiry Game and the three subscales of the WPPSI-III were examined at the fall time point. There was a significant positive correlation between the number of questions children asked and the WPPSI verbal reasoning score ($r = .266, p < .01$). This correlation indicates that children who asked more total questions (and therefore more HS questions) did better on Verbal Reasoning than those who used fewer questions.

Linear Regressions

Inquiry and vocabulary. The only significant relationship to emerge between inquiry skills and school readiness domains was a correlation with vocabulary knowledge. In order to more closely examine this relationship, a series of linear regressions were conducted in which vocabulary scores were regressed on inquiry scores at the concurrent point, with age and sex included as covariates. Sex did not significantly predict outcomes at any time point. Age was a significant predictor of inquiry outcomes at all three time points.

Fall vocabulary scores positively predicted fall inquiry scores, $F(3, 157) = 10.01, p < .01$; children with higher vocabulary scores in the fall asked more questions during the Inquiry Game at the fall time point, $b = .687, p = .036$. Age was a significant predictor of inquiry scores, $b = 3.22, p < .01$.

A linear regression with winter scores showed a reversal in the direction of this relationship. Vocabulary scores in the winter negatively predicted winter inquiry scores,

$F(3,157) = 13.11, p < .01$; children with higher vocabulary scores in the winter asked *less* questions during the Inquiry Game at the winter time point, $b = -.618, p = .034$. Age was a significant predictor of inquiry scores, $b = 3.96, p < .01$. A linear regression with spring scores revealed a trend in which vocabulary again negatively predicted inquiry skills, $F(3,157) = 10.51, p < .01$; children with higher vocabulary scores in the spring asked *less* questions during the Inquiry Game at the spring time point, $b = -.503, p = .052$. Age was a significant predictor of inquiry scores, $b = 3.19, p < .01$.

Inquiry and reasoning. When Matrix Reasoning and Verbal Reasoning were simultaneously entered as predictors of inquiry skills in a linear regression model ($F(3,156) = 5.824, p < .01$), results indicated that while higher Verbal Reasoning scores positively predicted asking more questions ($b = 1.07, p < .01$), Matrix Reasoning negatively predicted the number of questions asked during the Inquiry Game ($b = -.497, p = .027$), implying that children with higher matrix reasoning asked more CS questions. Thus, when verbal ability was controlled for, children's reasoning skills were related to the skills measured by the Inquiry Game.

Change in Inquiry Game scores. Differences in performance on the Inquiry Game at three time points were examined. A series of linear regressions revealed that inquiry scores in the fall predicted winter inquiry scores, $F(3, 143) = 2.85, p = .039, b = .200, p < .001$, but did not predict spring inquiry scores, $F(3, 145) = 1.173, p = .322, b = .129, p = .069$. Winter scores predicted spring inquiry outcomes, $F(3, 153) = 2.68, p = .049, b = .215, p = .008$. Age and sex were included as independent variables but did not significantly predict inquiry outcomes at any time point. Thus, the number of questions a child asked, and therefore the extent to which he or she used CS questions, changed over

the course of the school year; a child's utilization of CS questions in the fall did not predict the extent to which he or she did so in the spring.

These findings, along with the change in direction of the prediction of vocabulary to inquiry scores, indicate that highly verbal children asked more total (and therefore more HS) questions in the fall but were using more CS questions by the end of the year.

Models Predicting Growth in School Readiness

Latent growth models were analyzed to assess the ability of the Inquiry Game to predict growth in the four school readiness domains: vocabulary, math, listening comprehension, and alphabet knowledge. However, there was no significant variation in the slope parameter of any of the domains meaning that there were no significant differences in the rate at which children's skills grew throughout the year. The Inquiry Game, therefore, could not be tested as a predictor of growth in school readiness. Inquiry skills in the fall did not significantly predict baseline scores in any of the four domains. The following section presents the details of each growth model.

For vocabulary achievement, a linear growth model did not fit the data. There were no significant differences between residual variances across time, and the variance in slope was non-significant. Residual variances were therefore constrained to be equal across time and the variance in slope was constrained to zero; this linear model indicated adequate fit, $\chi^2(5) = 11.45, p = .053$; CFI = .965; RMSEA = 0.12. Inquiry skills, sex, and age were entered as predictors. Fit indices indicated adequate fit to the data, $\chi^2(8) = 12.01, p = .151$; CFI = .97; RMSEA = 0.08. The estimated grand mean score at the start of the school year was 205.76 ($SE = 4.06, p < .001$). For each month in school, children's vocabulary skills increased approximately 3.89 points ($SE = .483, p < .001$).

There was significant variance in baseline achievement (1068.29, $p < .001$). Age significantly predicted the intercept, ($b = 3.087$, $p < .001$). Sex was not a significant predictor of baseline scores. Performance on the Inquiry Game did not significantly predict baseline scores. Given that there was no variance in slope, predictors were not entered to examine predictors of growth over time.

For listening comprehension achievement, a linear model of growth showed good fit to the data, $\chi^2(1) = 1.669$, $p = .196$; CFI = .981; RMSEA = 0.086. The estimated grand mean scores at the start of the school year were 211.286 ($SE = 3.26$, $p < .001$). For each month in school, children's listening comprehension increased approximately 2.272 points ($SE = .468$, $p < .001$). There was no significant variance in baseline achievement (207.439, $p = .43$). The variance in slope was not significant ($-.559$, $p = .95$). As there was no variance in the intercept or slope, predictors were not added to the model.

For mathematics achievement, a linear model of growth did not fit the data. There were no significant differences in residual variances, and the variance in slope was non-significant. Residual variances were therefore constrained to be equal across time and, the slope was constrained to zero; this linear model indicated good fit to the data, $\chi^2(9) = 9.33$, $p = .096$; CFI = .973; RMSEA = 0.098. Inquiry Game, sex, and age were entered as predictors, and this model fit the data well, $\chi^2(8) = 9.55$, $p = .298$; CFI = .99; RMSEA = 0.05. The estimated grand mean score at the start of the school year was 203.1721 ($SE = 4.44$, $p < .001$). For each month in school, children's mathematics skills increased approximately 4.107 points ($SE = .436$, $p < .001$). There was significant variance in baseline achievement (1335.858, $p < .001$). Age significantly predicted baseline scores, ($b = 4.047$, $p < .001$). Sex was not a significant predictor of baseline

scores. Performance on the Inquiry Game did not significantly predict baseline scores. There was no variance in slope; predictors therefore could not be entered to examine differences in growth over time.

For alphabet knowledge achievement, a linear model of growth showed good fit to the data, $\chi^2(1) = 2.56, p = .10$; CFI = .986; RMSEA = 0.131. The estimated grand mean scores at the start of the school year were 216.929 ($SE = 5.423, p < .001$). For each month in school, children's listening comprehension increased approximately 3.18 points ($SE = .665, p < .001$). There was significant variance in baseline achievement (1954.32, $p < .001$). The variance in slope was not significant (13.917, $p = .309$). The Inquiry Game, sex, and age were entered as predictors. This model indicated good fit, $\chi^2(4) = 5.159, p = .271$; CFI = .987; RMSEA = 0.061. Age significantly predicted the intercept, ($b = 3.30, p < .01$). Sex was not a significant predictor of baseline scores. Performance on the Inquiry Game did not significantly predict baseline scores.

Chapter 4: Discussion

The purpose of this study was to create a measure that captures children's inquiry skills and to validate this measure using existing assessments of reasoning and school readiness. The results of the study indicate that the Inquiry Game captured a range of inquiry skills, and that these skills improved throughout the year, with the majority of improvement occurring between the fall and winter time points. The correlations with other measures, however, failed to conclusively establish concurrent and predictive validity.

Performance on the Inquiry Game in the beginning of the school year demonstrated that the task was appropriate for the population. The majority of children passed the screener and was able to follow the instructions and participate in the game. As hypothesized, the more popular inquiry style was to ask hypothesis-seeking questions; children asked about each picture in turn and did not make use of the categories to reach a solution more efficiently. Of the children who did use the constraint-seeking questions, there was a range in the number of such questions used throughout the game. These outcomes demonstrate that the measure is sensitive to a range of abilities. Further, the fact that most children did not use CS questions, or used them inconsistently implies that an intervention may be appropriate to bolster this skill.

When the task was administered again in the winter, children used fewer questions overall, indicating an increase in more efficient, constraint-seeking questions. While 30% of children still exclusively used the hypothesis-seeking strategy, the number of children who consistently used CS questions increased from fall to spring. While most of the improvement occurred from the fall to the winter, the mean number of questions

decreased slightly from the winter to the spring. This provides further indication that the Inquiry Game is measuring a skill that improves over time. .

Inquiry and Verbal Ability

Scores on the Inquiry Game were related to measures of verbal ability: the Vocabulary subtest of the Learning Express and the Verbal Reasoning subtest of the WPPSI-III. However, the change in direction of these associations over the course of the year makes it somewhat difficult to interpret the nature of this relationship. The following section will posit some possible explanations for these results.

Results indicate that a relationship exists between the number of questions asked during the Inquiry Game and verbal ability. In the fall, children with better vocabulary and verbal reasoning skills asked more questions to arrive at the solution in the Inquiry Game, more often relying on hypothesis-seeking inquiry. However, this relationship changed throughout the year. Whereas children with higher verbal ability in the fall asked more questions during the fall assessment of inquiry, these children asked fewer questions in the winter and spring, more often relying on constraint-seeking inquiry. The findings for the winter and spring scores are consistent with the hypothesis that using constraint-seeking questions, and therefore asking less questions overall, is a more advanced skill and is correlated with better school readiness outcomes, particularly vocabulary skills.

Although these findings seem counter-intuitive at first glance, considering the aptitudes that are captured by these measures, as well as the progression of these abilities over the course of the school year, may help to explain this pattern of results. The finding that inquiry skills in the fall and spring were not correlated reveals, importantly,

that the extent to which children asked constraint-seeking questions varied throughout the year. Children who used predominantly constraint-seeking questions in the fall did not necessarily maintain this strategy in the winter and spring, and vice versa.

One potential reason for this finding is that, at the beginning of the school year, the inquiry skills necessary to play the Inquiry Game most efficiently have not yet begun to emerge for many children. Children's performance on the task, then, may not be a reflection of inquiry skills per se but of various other skills and motivations. It is important to note that past research using similar assessment methods has found that preschool children rarely use constraint-seeking questions, as this skill is only beginning to emerge at this age (Courage, 1989; Denney & Connors, 1974; Mosher and Hornsby, 1966; Thornton, 1999). It is possible, then, that children with higher vocabulary and verbal reasoning abilities may have, in fact, understood the instructions better but had not yet developed the skills needed to use the more efficient inquiry strategy and so attempted to figure out the solution by asking about each picture one-by-one. Conversely, children with lower vocabulary and verbal reasoning abilities were more likely to use constraint-seeking questions at the first time point because they were more likely to imitate the strategy used by the assessor during modeling, or respond to the social demand to please the assessor. As inquiry skills developed throughout the year, children with higher vocabulary and verbal reasoning skills may have begun developing and employing the more efficient type of questions, while children who did not understand the task at the first time point now used more hypothesis-seeking questions to solve the problem. This may have resulted in a reversal of the direction of the correlation in the winter and spring.

It is also possible that the disparity in the direction of these correlations is due to the novelty of the assessment. In the beginning of the year, children who have higher vocabulary skills may be more outgoing and willing to engage with the assessor, and therefore ask more questions in order to prolong the game. When the assessment was administered for the second and third time, children may have been less attracted by the novelty of the game and consequently paid greater attention to the intended task. Thus, winter and spring time points may reveal a more valid assessment of children's inquiry skill, with children with higher vocabulary skills demonstrating higher inquiry skills.

Inquiry and Problem Solving

When verbal reasoning was controlled for, matrix reasoning emerged as a significant predictor of inquiry skills. This relationship provides support for concurrent validity of the Inquiry Game, as both the Inquiry Game and Matrix reasoning are problem-solving tasks in which children are asked to use category membership to arrive at a solution. While the Verbal Reasoning subtest requires children to provide verbal responses, the Matrix Reasoning subtest does not. This finding lends further support to the theory that verbal reasoning taps into general scholastic aptitude, or overall verbal responsiveness, and that when this is controlled for, the relationship between inquiry skills and matrix reasoning emerges. This explanation is consistent with the hypothesis explaining the relationship between verbal outcomes and inquiry scores. This result may indicate that at this age, vocabulary knowledge or verbal reasoning ability actually capture general ability, or responsiveness to tasks such as the Inquiry Game, and that, at a first exposure, children who score highly in these areas attempt to solve the problem by relying more heavily on the only inquiry skill cognitively available to them, or

hypothesis-seeking inquiry. As reasoning and inquiry skills develop over the course of the school year, vocabulary skills still stand as a proxy for overall academic ability or responsiveness but that at this point, children with higher skills in these areas begin understanding how constraint-seeking questions make solving the problem more efficient and demonstrate use of this technique.

Inquiry and School Readiness

Scores on the Inquiry Game were not correlated with mathematics, listening comprehension, or alphabet knowledge scores, or the Similarities subscale of the WPPSI-III. The hypothesis that these measures would correlate with the Inquiry Game was based on research and theory that identifies inquiry as a skill that can help increase understanding and ability in multiple academic domains. Inquiry, or the ability to ask questions, however, is composed of multiple components and can refer to several types of abilities. The capacity to ask a question during a lesson is qualitatively different from the inquiry skill necessary to reason about and employ an efficient strategy in order to figure out a solution to a problem. Math and literacy are often taught in preschool through repetition and memorization activities that do not require use of efficient problem-solving techniques; this type of inquiry may therefore be unrelated to outcomes in mathematics, listening comprehension, and alphabet knowledge. In addition, there were no significant differences in children's rates of growth in any of the four domains; the hypothesis that inquiry in the fall would predict growth in school readiness therefore could not be examined.

Finally, it is possible that the Inquiry Game, in its current form, does not consistently capture the skills that it was designed to assess. It may be that for children of

this age, the desire to engage in the activity is stronger than the desire to solve the problem efficiently. There is no tangible benefit to asking constraint-seeking questions; and no punishment for asking a question about every picture. Therefore, children may not be sufficiently motivated to use the more efficient, constraint-seeking style of inquiry. This may be especially true in the fall, when the game is most novel and children are younger and unaccustomed to assessment. Future work will consider alternate strategies to increase motivation to solve the problem efficiently and better tap into children's ability to employ constraint-seeking questions.

Limitations and Future Directions

The current study contributes to the literature on inquiry skills in young children, as well as children from at-risk populations. Although extant research and theory identify the ability to ask questions as an important domain-general skill, little is known about how this skill develops. The Inquiry Game is an appropriate and sensitive assessment for a population of preschoolers from low-income backgrounds. Data from the current study contribute to this field of research by capturing children's ability and frequency of use of the different inquiry strategies, and the way in which this ability changes throughout the preschool year.

Despite these contributions, this study possesses some limitations. First, this study was conducted in five Head Start centers located in urban areas and serving predominantly African-American children. Therefore, this study should be replicated in other geographic and ethnic samples and cannot be generalized to other populations.

Young children's use of inquiry and its potential benefits is a relatively unexplored domain. In order to establish validity, measures that capture children's

reasoning and school readiness were employed. However, these measures were not designed to capture inquiry skill and may therefore be inadequate tools to establish validity of the designed assessment. Future studies should attempt to identify measures that more closely capture similar abilities to those assessed by the Inquiry Game. In addition, children were only assessed on the WPPSI subscales at the fall time point. Examining performance in the Inquiry Game, as well as other reasoning tasks as they change concurrently over time, may provide insight into the relationship that emerged at the first time point and should be included in future replications.

The design of the Inquiry Game was based on research, as well as previous work, that identified techniques that would make the assessment appropriate for this sample. However, this task taps into a skill that is still developing and that children are rarely asked to employ. It is possible that the design of this assessment did not sufficiently model the use of constraint-seeking questions, or was not administered in a way that provided the children with sufficient motivation to use an efficient inquiry strategy, and therefore did not fully capture their ability to use this skill. Future work should examine other modeling techniques, as well as other strategies to encourage efficient inquiry use.

Finally, the correlations that emerged from this study are inconclusive and require further investigation. It is important to note that this study was the first to examine inquiry and its relationship to other readiness skills using the Inquiry Game and was largely exploratory in nature. The results that emerged have not been replicated, and the findings must therefore be treated with caution. Future work should replicate this study in similar, as well as more diverse populations, to better understand the relationship between Inquiry Game outcomes and verbal reasoning and vocabulary skills. If results

from the current study are replicated, future studies should employ Structural Equation Modeling or Hierarchical Linear Modeling to examine whether latent classes can be identified based on performance on these measures, as well as how performance changes throughout the school year.

Chapter 5: Conclusion

Inquiry is a domain-general skill that has the potential to promote school readiness in low-income preschoolers who are behind academically (National Research Council, 1996; Weatherholt et al., 2006). Although past research has demonstrated that inquiry through question-asking is a developing skill in early childhood, more work is needed to understand this ability in young children. Based on existing research, a measure was developed and tested in the current study to capture inquiry skills of young children from at-risk backgrounds. Results of the investigation indicate that the ability to use questions to efficiently solve problems is an emerging skill in this population. The Inquiry Game was able to identify different levels of this skill, as well as capture an increase in use of efficient questions over time. Development of sensitive, appropriate measures is an important step towards supporting academic growth of children from low-income homes. These findings lay a foundation for future research in this domain within an underserved population.

Before research on inquiry skills can be practically applied to the preschool classroom, more research is needed that empirically investigates the relationship between inquiry and school readiness in young children. The inconclusive findings of this study highlight the need for further research in this area. The foundation laid by this research can aid in furthering our ability to understand and support low-income children's questioning and reasoning skills. Current findings suggest that these skills are not well developed within this population; a greater focus on questioning in education is therefore warranted. Interventions and teacher-training that expose children to the use of inquiry as a tool for learning and promote those skills at an early age have the potential to lead to

better outcomes in all readiness domains. Further development of valid assessment tools for inquiry in young children, however, is necessary for advancing our understanding of these skills, and, in turn, how to promote their development.

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Table 1

Number of Participants, Means, and Standard Deviations For All Three Time Points.

| | N | Mean | Standard Deviation |
|--------------------------------|-----|--------|--------------------|
| Inquiry Game | | | |
| Fall Inquiry | 158 | 37.22 | 8.50 |
| Winter Inquiry | 160 | 34.04 | 9.89 |
| Spring Inquiry | 164 | 34.06 | 10.04 |
| WPPSI-III | | | |
| Fall Matrix Reasoning | 157 | 8.25 | 3.12 |
| Fall Word Reasoning | 157 | 7.23 | 2.59 |
| Fall Similarities | 157 | 8.39 | 2.51 |
| School Readiness | | | |
| Fall Math | 180 | 204.53 | 41.19 |
| Winter Math | 174 | 224.12 | 39.41 |
| Spring Math | 169 | 233.92 | 43.33 |
| Fall Vocabulary | 180 | 210.07 | 41.31 |
| Winter Vocabulary | 174 | 222.99 | 40.68 |
| Spring Vocabulary | 169 | 235.54 | 35.97 |
| Fall Listening Comprehension | 180 | 215.87 | 29.93 |
| Winter Listening Comprehension | 174 | 219.26 | 37.35 |
| Spring Listening Comprehension | 169 | 228.79 | 29.94 |
| Fall Alphabet Knowledge | 180 | 212.99 | 50.43 |
| Winter Alphabet Knowledge | 174 | 231.88 | 48.31 |
| Spring Alphabet Knowledge | 169 | 243.58 | 43.56 |

Table 2

Detailed Analyses of Inquiry Game Performance At Each Time Point: Percentage of Children Who Passed Screener, Cronbach's Alpha, Mean Scores, Standard Deviations, Z-score Distributions of Scores, Percentage of Children Using Only HS Strategy, and Percentage of Children Using Only CS Strategy

| | Fall | Winter | Spring |
|----------------------|--------------|--------------|---------------|
| Passed Screener (%) | 87.3% | 94.67% | 95.9% |
| Chronbach's Alpha | .73 | .81 | .88 |
| Mean Score (SD) | 37.22 (8.25) | 34.84 (9.89) | 34.06 (10.04) |
| Z-score Distribution | -2.26 – 1.15 | -1.82 – 1.11 | -1.6 – 1.09 |
| HS strategy only (%) | 37% | 30.4% | 34.8% |
| CS strategy only (%) | 7.6% | 20% | 20.7% |

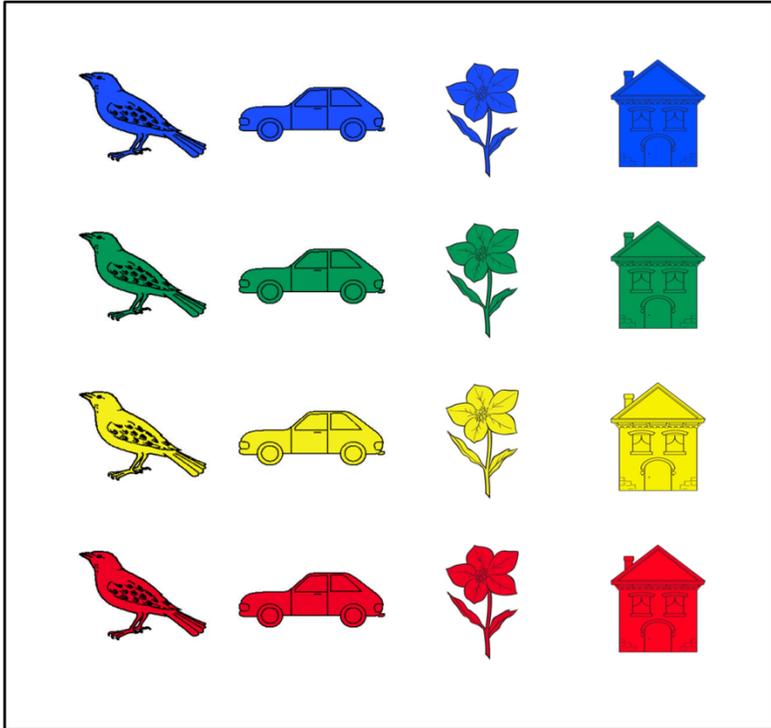


Figure 1. Array of pictures seen in Item 1 of the Inquiry Game.

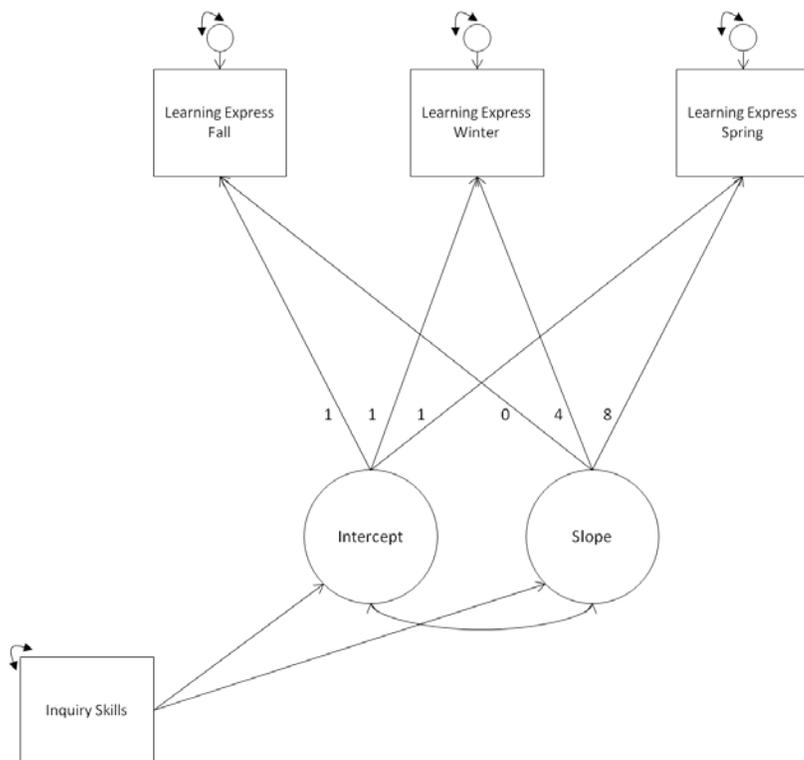


Figure 2. Inquiry skills predicting growth in school readiness (one model for each domain: mathematics, vocabulary, listening comprehension, and alphabet knowledge) as measured by the Learning Express in fall of 2010, winter of 2011, and spring of 2011. Demographic variables of age, sex, and ethnicity were controlled for in the analyses.

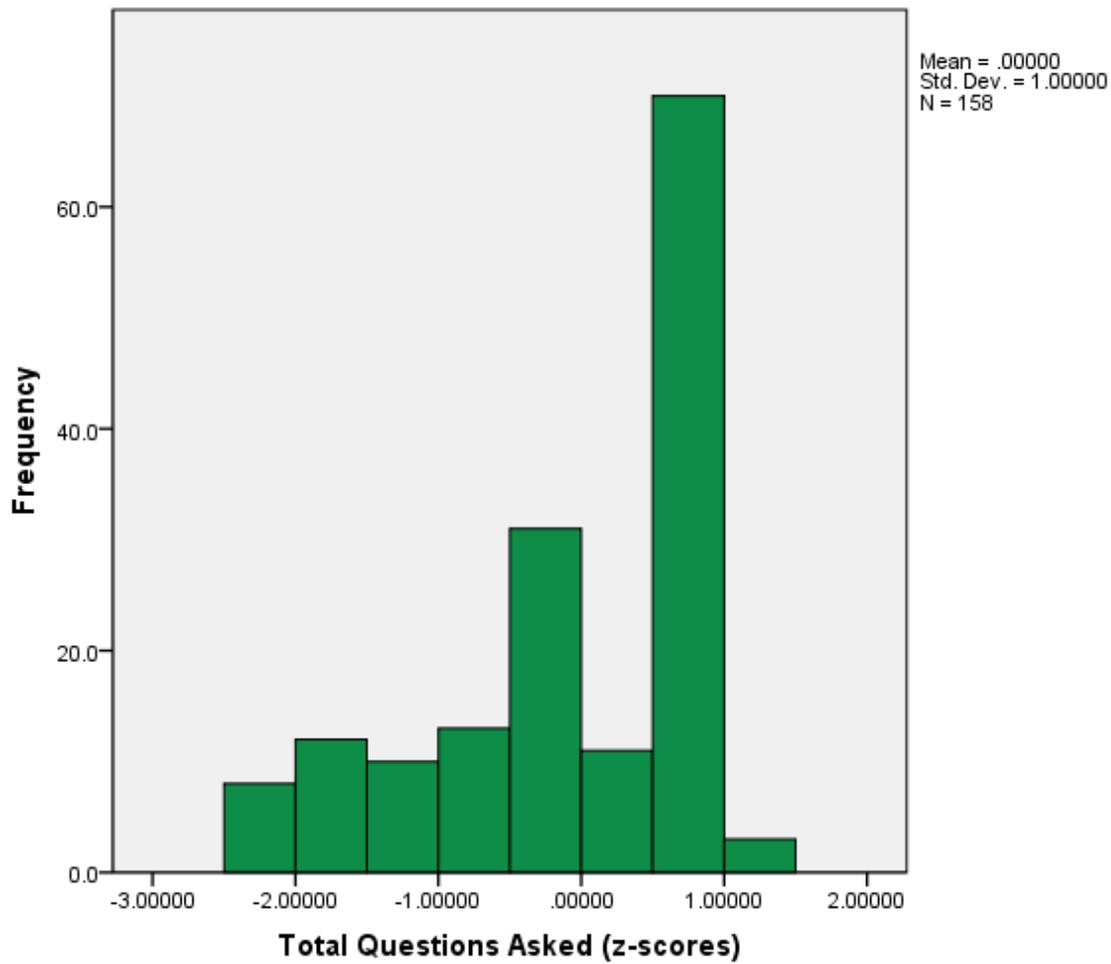


Figure 3. Z-score distribution of total questions asked during Inquiry Game assessment, fall of 2010.

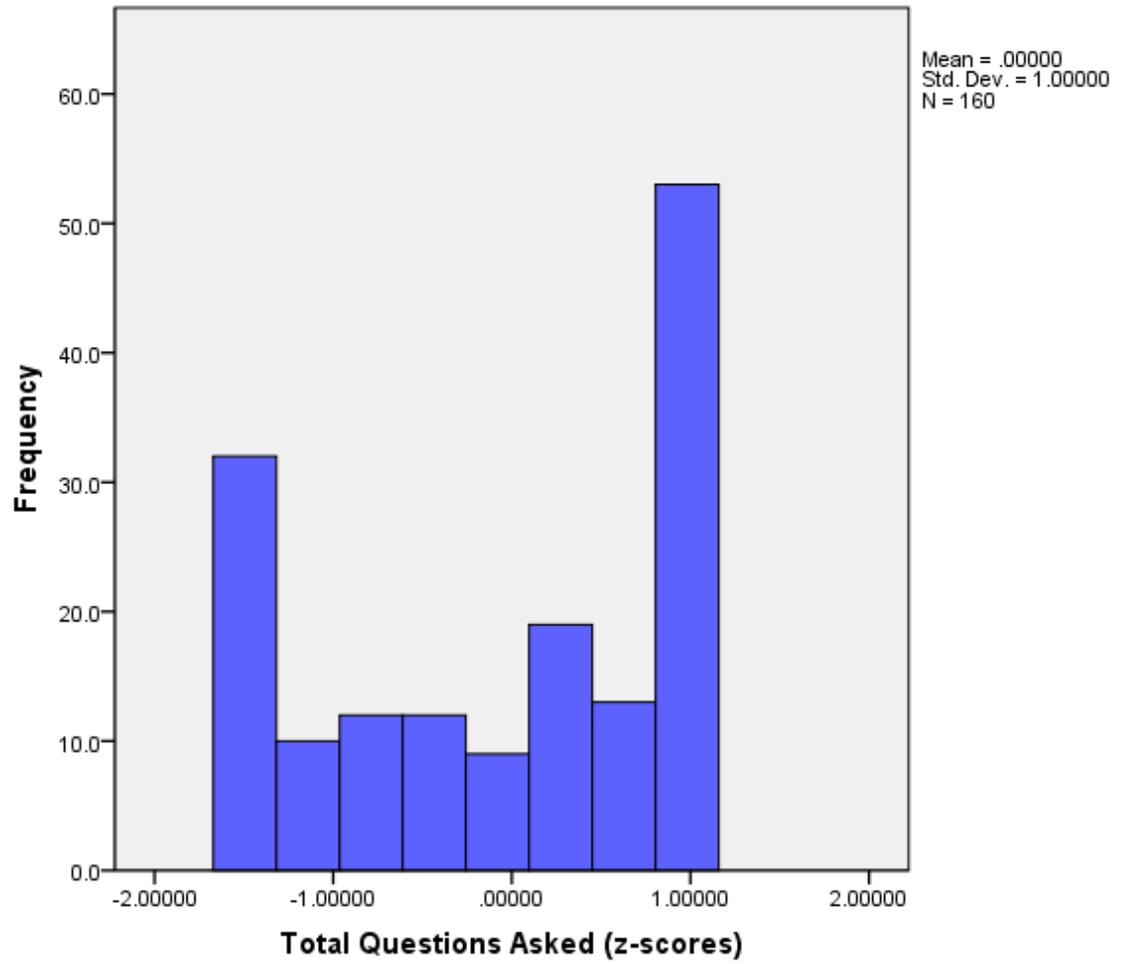


Figure 4. Z-score distribution of total questions asked during Inquiry Game assessment, winter of 2011.

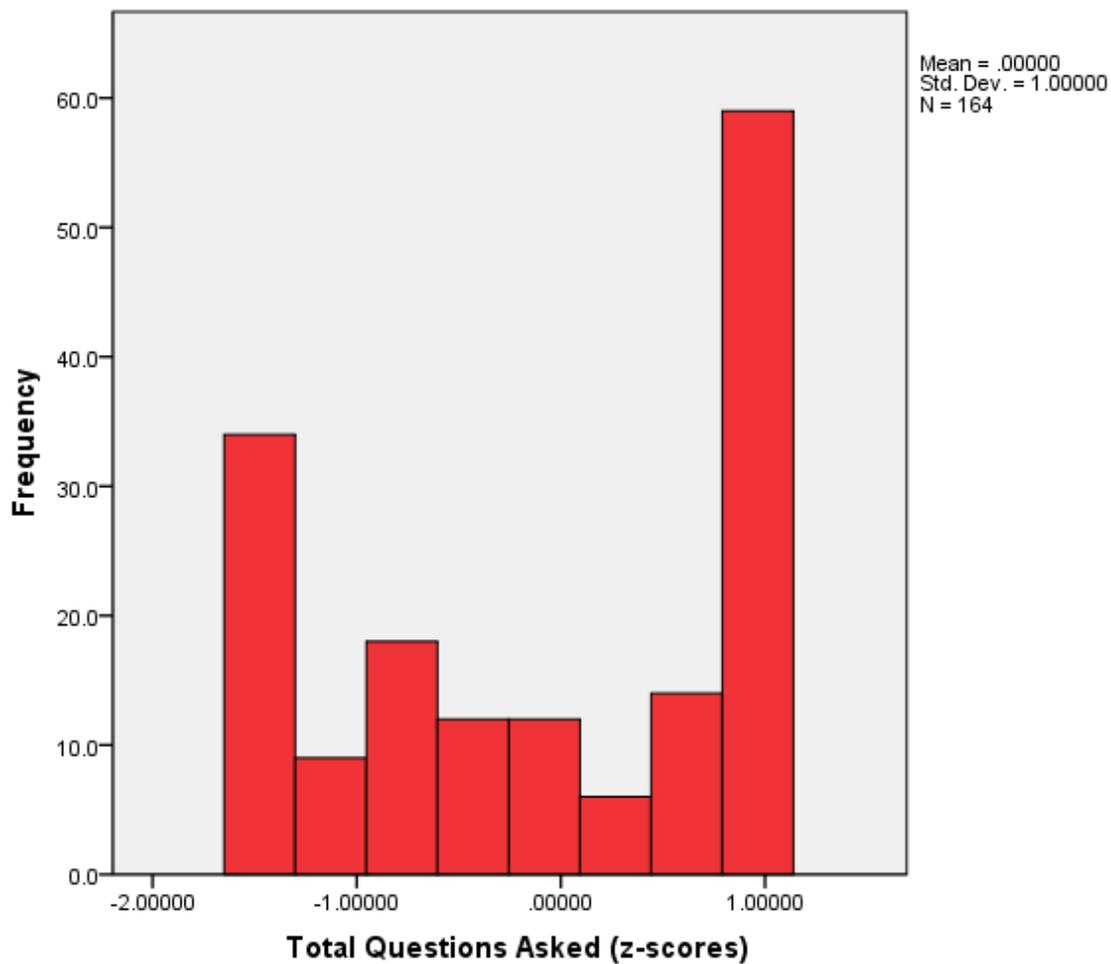


Figure 5. Z-score distribution of total questions asked during Inquiry Game assessment, spring of 2011.