Western Kentucky University
TopSCHOLAR®

Masters Theses & Specialist Projects | Graduate School

5-1-2011

# Development of a Math Interest Inventory to Identify Gifted Students from Underrepresented and Diverse Populations

Gabrielle M. Snow
*Western Kentucky University*, gabrielle.frassinelli@topper.wku.edu

Follow this and additional works at: http://digitalcommons.wku.edu/theses

Part of the Gifted Education Commons, School Psychology Commons, and the Science and Mathematics Education Commons

Recommended Citation
Snow, Gabrielle M., "Development of a Math Interest Inventory to Identify Gifted Students from Underrepresented and Diverse Populations" (2011). *Masters Theses & Specialist Projects*. Paper 1052.
http://digitalcommons.wku.edu/theses/1052

This Thesis is brought to you for free and open access by TopSCHOLAR®. It has been accepted for inclusion in Masters Theses & Specialist Projects by an authorized administrator of TopSCHOLAR®. For more information, please contact connie.foster@wku.edu.

# DEVELOPMENT OF A MATH INTEREST INVENTORY TO IDENTIFY GIFTED STUDENTS FROM UNDERREPRESENTED AND DIVERSE POPULATIONS

A Specialist Project
Presented to
The Faculty of the Department of Psychology
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Specialist in Education

By
Gabrielle M. Snow

May 2011

DEVELOPMENT OF A MATH INTEREST INVENTORY TO IDENTIFY GIFTED STUDENTS FROM UNDERREPRESENTED AND DIVERSE POPULATIONS

Date Recommended 1/17/2011

Elizabeth L. Jones

Dr. Elizabeth Jones, Co-Director of Thesis

Steven R. Wininger

Dr. Steven Wininger, Co-Director of Thesis

Carl Myers

Dr. Carl Myers

Richard H. Bowker May 16, 2011

Dean, Graduate Studies and Research Date

Acknowledgments

My thesis project would not have been possible without the continuous work of my thesis co-directors, Dr. Elizabeth Jones and Dr. Steven Wininger, and committee member, Dr. Carl Myers. Many hours were spent reading, revising, and meeting during my graduate career and I would not have been able to develop such an individual piece without their support and time. More specifically, thank you Dr. Elizabeth Jones for your patience and exceptional way of aiding me in the task of putting my thoughts into written words. I would like to show my gratitude to my parents, Ken and Kim Frassinelli, for always supporting me in my school endeavors and appreciating my love and interest for education. Most importantly, my husband Ryan has been a critical proponent for my continuation and involvement in education. He has always been my support for which I have built my education, career, and life. Thank you all.

Table of Contents

Pages

List of Tables ……...……..... v

Abstract ……..……..……...……..... vi

Introduction ..... 1

Literature Review ……...…..... 3

Method …… 19

Results ……..... 24

Discussion ……...… 37

References ……... 43

Appendix A: …… 46

Appendix B: …… 49

Appendix C: ..... 52

List of Tables

Page

Table 1: Hidi and Renninger's (2006) Key Characteristics of the Four-Phases of Interest Development …...…….…….……..... 13

Table 2: Six Potential States of Interest …….…….. 21

Table 3: Descriptive and Item-Analysis Statistics for the Math Interest Measure…..…..... 25

Table 4: Pattern Matrix for Five-Factor Model for the Math Interest Measure: Factor Loadings …..... 29

Table 5: Pattern Matrix for Four-Factor Model for the Math Interest Measure: Factor Loadings …….....…. 30

Table 6: Factor Loading for Final Inclusion in the Math Interest Measure ..... 34

Table 7: Correlations Among the Interest Subscales, Composite Scores, and ITBS Math Scores ……..…….....… 36

DEVELOPMENT OF A MATH INTEREST INVENTORY TO IDENTIFY GIFTED STUDENTS FROM UNDERREPRESENTED AND DIVERSE POPULATIONS

Gabrielle Marie Snow May 2011 53 pages

Directed by: Dr. Elizabeth Jones, Dr. Steven R. Wininger, and Dr. Carl Myers

Department of Psychology Western Kentucky University

The current investigation supports the objectives of Project GEMS (Roberts, 2008), a grant funded program whose objectives include the development and validation of a protocol to identify students from underrepresented and diverse populations as gifted in the content areas of science, technology, engineering and mathematics. Identification of students from low-income and diverse populations as gifted has been a struggle with current assessment techniques (Baldwin, 2005). Project GEMS aims to address this problem through development of interest measures specific to the STEM areas for use within an identification protocol. The current project developed a measure to assess interest in mathematics. The construct of interest was targeted as it is correlated with many positive factors in education that lead to increased academic performance (Schunk, Pintrich, & Meece, 2008). Existing math interest inventories are designed for older populations, lack good psychometric properties and are atheoretical. To improve upon existing interest measures, Hidi and Renninger's (2006) four-phase model of interest served as the theoretical basis to inform and guide the process of development and validation of a math interest inventory. A twenty-seven item self-report math interest measure was designed to assess the four phases of Hidi and Renninger's interest model (emotion, value, knowledge, and engagement; 2006). Pilot and field testing of the measure were conducted in elementary schools selected on the basis of a high proportion

of low-income students in a south central Kentucky school district. The sample consists of 1,429,429 students in grades two through six. The measure was hypothesized to evidence good internal consistency, a four-factor structure, and a significant and positive correlations between the Iowa Test of Basic Skills and the composite and subscales of the math interest inventory. The first hypothesis found support with an internal consistency reliability coefficient of .916 for the overall score. Results of confirmatory factor analysis supported a four-factor structure resembling Hidi and Renninger's (2006) four phase model of interest and including the four components emotion, value, knowledge, and engagement. The correlations between the math scores from the Iowa Test of Basic Skills and the math interest inventory total score and scales partially supported the last hypothesis. The correlations were small and positive for the Values and Knowledge scales but small and negative for the Emotion and Engagement scales. The correlations for the total score of the math interest inventory were significant; however, their values had little practical significance. While the math interest measure evidences good reliability and support for the structure of the scales through confirmatory factor analysis, the current study did not provide evidence for a significant relationship with math achievement as measured by a standardized group administered math achievement test. These results are discussed in relation to limitations of the current study and recommendations for further investigation.

# Introduction

Project GEMS (Gifted Education in Math and Science; Roberts, 2008) is a grant funded by the U.S. Department of Education to "design and implement a model demonstration project that will increase the number of elementary children who are advanced in science and math and to foster their interest and achievement in science, technology, engineering and mathematics (STEM; p i)." Children from underrepresented populations such as low-income and minorities, are the target populations of interest as they are underrepresented in STEM careers. The current investigation supports one objective of the grant, which is to develop a protocol for identifying and fostering interest and achievement in STEM areas. Specifically, this investigation focuses on the development and validation of a self-report inventory to identify interest level in mathematics. This math interest inventory along with inventories developed in science, engineering and technology, combine with the Iowa Test of Basic Skills and Cognitive Abilities Test, and referrals from teachers to comprise the Project GEMS identification protocol. By using interest along with ability and teacher referral within the identification process, Project GEMS purports to better ensure the identification of children from underrepresented backgrounds with high interest, in order to further foster interest and achievement in the STEM areas.

The underrepresentation of students from diverse populations identified as gifted in mathematics is a problem for schools in the United States (National Association for Gifted Children [NAGC], 2009). The causes of this insufficiency are unknown and the problem must be analyzed. There are some shortfalls in gifted identification programs that may lead to the problem of underrepresentation of diverse populations. One

suggestion to improve the identification of underrepresented students from diverse populations is to assess interest in mathematics during the identification process. Interest is correlated with many positive factors in education that lead to increased academic performance (Schunk, Pintrich, & Meece, 2008). Assessing math interest, as one component of Project GEMS (Roberts, 2008) identification protocol, should increase the likelihood of identifying students with the potential for high performance in mathematics. Hidi and Renninger's (2006) four-phase model of interest provides a theoretical framework for examining an individual's level of interest and will serve to inform and direct the development of a math interest inventory

The following literature review will provide a basis for the current investigation by providing a review of existing identification protocols and the need, to improve the identification of students from underrepresented and diverse populations. First, common problems in identifying gifted students will be addressed. Second, problems with assessing and identifying students as gifted from underrepresented populations will follow. Last, Hidi and Renninger's (2006) model for understanding the development of interest is reviewed along and the relationship between interest and achievement. This model provides the theoretical basis for developing the interest inventory in mathematics.

## Literature Review

The public does not always view the quality of education in the United States positively. A headline in the *Wall Street Journal* read, "Economic Time Bomb: U.S. Teens Are Among the Worst at Math" (Kronholz, 2004) insinuates that if American children are not able to obtain a competitive education in comparison with the rest of the world, they will not be able to prosper? This issue prompts a debate about what can be done in schools to not only help current students, but also secure a successful future for the country.

Two prominent assessment reports provide comparisons of academic achievement results among numerous countries and serve as the sources for the noted *Wall Street Journal* heading noted above. The government report, *Trends in International Mathematics and Science Study* (*TIMSS*), analyzes information regarding what students should be learning in mathematics and science in fourth and eighth grade, and how well they know the material (National Center for Education Statistics [NCES], 2007). This 2007 report shows that U.S. students in fourth grade rank eleventh and eighth grade students rank ninth in mathematics internationally (NCES, 2007). Another study conducted by the Program for International Assessment (PISA) measures 15-year-old students in mathematical areas such as interpreting mathematical problems, knowledge of mathematical procedures, and translating mathematical procedures (2007). The results indicate that United States students rank 24th out of 29 countries. These reports suggest that students from the United States are not globally competitive. It is unknown from the NCES (2007) reports if the pattern for students in the general population is similar to students from the gifted population, the population on which this project focuses. The

legal mandate of the No Child Left Behind legislation (NCLB; U.S. Department of Education, 2010) is to identify students that are at a high risk for academic failure and to implement strategies to improve their educational scores and success. NCLB mandates impacts educational practices with an emphasis on needs of students that are inadequately progressing. Because schools are focusing on inadequately progressing students, it calls into question whether or not the needs of gifted students are being met. Students participating in programs for the gifted are defined by The National Association for Gifted Children (NAGC) as those who:

> Give evidence of higher performance capability in such areas as intellectual, creative, artistic, or leadership capacity, or in specific academic fields, and who require services or activities not ordinarily provided by the schools in order to develop such capabilities fully. (NAGC, 2011, para. 1).

NCLB has focused the attention on students who are lower functioning rather than the higher functioning gifted students. Because of this shift, the long-term impact and consequences for gifted programs are unknown.

The United States education system requires not only compulsory attendance of all children, but in addition, that education is provided to students with equal opportunity. The requirement includes children from all cultures and economical backgrounds. Students from underrepresented populations may be at a disadvantage for selection to gifted programs. The NAGC (2009) states:

> High-ability learners span all cultures, races, classes, and backgrounds. However, our nation often fails to identify and serve the gifted students who are the most disadvantaged. As a result, the achievement gap between the highest-performing

> students from disadvantaged backgrounds and their more affluent peers grows at a faster rate than it does for students at the opposite end of the achievement spectrum. (p. 1)

The term "underrepresented" can include inadequately represented children such as ethnic minorities, those with a limited English ability, and children that come from families in low socioeconomic status environments (Callahan, 2005). High-achieving low-income students drop out of school twice as often and are less likely to attend or graduate from college, when compared to high-achieving high-income students (NAGC, 2009). The existing process of identification of students may be insensitive to selecting underrepresented students for gifted programs. Only 9% of the total populations of gifted children are from low-income families (Callahan, 2005).

*Assessment of Underrepresented Youth*

A current concern in the field of gifted education is how to identify students from underrepresented diverse populations for gifted services. Baldwin (2005) declares two concerns: the problems associated with the identification process and the assessment techniques. Intelligence tests have historically been one of the prime indicators of giftedness in school systems. There has been increasing support for the opinion that the use of intelligence tests may not be the best means to identify these students.

One important note to highlight is that intelligence tests are not the sole indicator of a person's cognitive abilities. Renzulli (1978) suggests that in order to identify high-potential students accurately, one must use a guide that encompasses the Three-Ring Conception of Giftedness theory. The integrated theory includes learning, motivation, and creativity with the already known concept of cognitive ability. Additionally,

Renzulli purports that a math identification screener that would include the idea of interest as an indicator of motivation could help assess mathematical giftedness. Therefore, other sources of information, besides cognitive only-based ability assessments, should be included when assessing for giftedness.

Experts suggest an assessment approach such as the Baldwin Identification Matrix, which helps to encompass more information (cognition, creativity, psychosocial, and psychomotor) into the assessment process (Baldwin, 2005). This particular model is based on the assumptions that (a) giftedness from underrepresented populations is conveyed through multiple behaviors where giftedness in one dimension is just as important in other areas, (b) that giftedness can be developed and expressed through different domains, and (c) every culture has individuals exhibit behavior that can be interpreted as signs of giftedness. Thus, Baldwin would advocate for both a broad definition and conceptualization of giftedness. This approach would be different from the prior approach, which primarily uses intelligence tests, in that it would provide assessors with more pertinent information.

Callahan (2005) recognizes that there are other concerns when identifying gifted students from underrepresented populations including, "definitions of giftedness, the use of 1-shot paper-and-pencil assessments, the inherent biases in policies and procedures, and the lack of coordination of curriculum with identification and placement procedures" (p. 98). Callahan agrees with Baldwin's approach to utilizing more than just a single assessment in the identification process. Such a multi-method approach would include the use of multiple assessment techniques (i.e. rating scales, cognitive assessment, teacher nominations) to more accurately assess and identify students as gifted (Callahan,

2005). Second, current mathematical assessment tools do not take into account differences in acculturation and are, therefore, not sensitive to students from diverse backgrounds. The solution associated with this problem is to develop the conceptualization of giftedness and utilize assessment tools that are not solely based on school curriculum.

The TIMSS (NCES, 2007) assessment indicates that fourth grade Hong Kong math students rank number one, and that eighth grade Hong Kong math students rank fourth on the list of cross-cultural comparisons. These high rankings suggest that the educational system in Hong Kong is facilitating achievement in mathematics and should be examined to evaluate reasons for their success. The school systems in Hong Kong have had similar issues to the United States with determining how to identify their gifted students. Chan (2000) notes that Hong Kong's education system prior to the 1970s did not have a need for an identification system for gifted students because education was not a requirement for all children. Once education was mandatory, a program for gifted students developed. The immediate concern was how to assess these children for giftedness. Their approach included a multi-method tactic incorporating intelligence tests, achievement assessments, behavioral rating scales like the Scales for Rating Behavioral Characteristics of Superior Students (SRBCSS; Renzulli, Smith, White, Callahan, & Hartman, 1976) and parent and teacher nominations. The administrators and assessors in the Hong Kong educational system was able to use this broaden assessment process to their advantage. While this identification process may just be one variable contributing to higher ranking in mathematics, it is logical to assume better identification has contributed to the higher educational attainment of their students.

A review of the literature identified several assessment approaches designed to address the issues in identification of giftedness in students from underrepresented populations in the United States. The next section provides a review of criteria felt to be appropriate for an identification protocol and a discussion of each identified program relative to the criteria. Callahan (2005) advocates for an approach that recommends the use of the following ten components: (a) expand conceptions of the definitions of intelligence and giftedness, (b) provide exemplars of gifted performance and use the identification process to enhance understanding, (c) develop a program for talent development, (d) identify early and often, (e) use valid and reliable assessment tools, (f) use authentic assessments, (g) gather data over time and use portfolios, (h) eliminate policies or practices that limit the number served in the gifted program, (i) rewrite procedures for nomination, screening, and identifying to reflect an inclusive, expanded definition of giftedness, and (j) match curriculum and services to the identification procedure. Callahan (2005) suggested that a combination of these variables would lead to an effective and efficient identification system; however, a measure that accurately identifies elementary students from disadvantaged populations has yet been created.

Kornhaber (1999) explores three different components to identifying gifted children from underrepresented populations that purport to assist in identifying these specific students. DISCOVER, which stands for Discovering Intellectual Strengths and Capabilities through Observation while allowing for Varied Ethnic Responses, is a popular method because of its intention to identify gifted students from diverse populations (Saraouphim, 1999). The identification process is comprised of activities administered by the general education classroom teacher and a DISCOVER assessment

team including individually administered mathematics and writing worksheets, small group assessments, and rankings from the observer team over the previous tasks. This program addresses a few of Callahan's (2005) list of solutions including the strength of using multiple screeners and information; however, it does not address the issue of gathering data over time.

The Problem Solving Assessment (PSA) is another assessment approach that assesses children from diverse populations (Kornhaber, 1999). Teachers supply specific lesson plans and record students' reactions, as well as obtain mathematical and linguistic assessments. This assessment meets some of Callahan's (2005) criteria, such as using multiple screeners and using authentic assessments that emphasize real world tasks. It does not, however, involve gathering data over time that is beneficial to obtaining an accurate representation of the child's talents.

A fourth approach is the Gifted Model Program which was designed to identify gifted students who are second language English speakers, learning disabled gifted students, and/or children from low socioeconomic status families (Kornhaber, 1999). This program's approach is different from the previous assessment methods for identifying giftedness because it uses standardized achievement and intelligence tests, teacher checklists, in-school or community nominations, and parent nominations. Therefore, it clearly is more comprehensive because it uses multiple sources to obtain student information, and it requires that data be obtained over time. The program still lacks in meeting Callahan's (2005) condition of using an authentic assessment tool that would emphasize and include tasks and situations that are part of the child's life.

Overall, each of the reviewed assessment models utilizes common components as using multiple informants and authentic assessments, which meet Callahan's criteria to some extent. However, all of the models appear to lack the criteria of evidencing psychometric support, which is a crucial component of any applicable measure. This would suggest that there is still a need for an empirically validated, gifted identification protocol that addresses the underrepresented populations concern. One component that is not addressed in any of these identification models is the idea that interest can be identified as a motivator. Interest in a content area is correlated with many positive factors in education that lead to increased academic performance (Schunk, et al., 2008).

*Interest*

Interest, as defined by the Merriam-Webster Dictionary (2010), is "a feeling that accompanies or causes special attention to an object or class of objects" (Definition, para. 1). Interest is a motivational variable that is linked with educational attainment in that students are more likely to engage in an academic activity, pay more attention, and generate higher performances if they are interested in the topic (Schunk et al., 2008). Attention to interest can be dated back into the 1800s where philosophers combined the topic of interest with motivation and learning. In the 1900s, psychologists added to the theory that person's attitude and/or a specific situation can impact one's interest in a topic. Personal attitude or interest depends on the person and his/her disposition toward a subject. Situational interest depends on the characteristics of the context and or situation; such as text, materials, content tasks, activities, classroom, and context. Shortly after, the research on interest quickly dissipated when behaviorism became a flourishing topic in psychology. It has not been until recent years that research has shifted back to exploring

how interest directly affects learning. Hidi and Renninger (2006) note that motivational variables are different from interest, in that interest can include both an affective and cognitive component. Affective and cognitive variables both have a biological basis while one's interest comes from not only themselves but also the content.

General perspectives of interest described by Krapp, Renninger, and Hidi (1992) explain the interactions of affect with knowledge and values. Personal interest reflects one's stable disposition relating to a topic and can vary greatly depending on the person. It can also be a view of a personal characteristic. For example, if someone likes something, gets enjoyment out of it, or sees it as important, then it usually indicates the person has a personal interest. Situational interest involves the actual "state" of being interested. Situational interest reflects a changing and situation-specific attention toward a topic that may increase with the right external factors such as texts and media. This type of interest can lead to personal interest because it can include both positive affect and increased attention, leading toward a static interest in the task. Hidi and Renninger's (2006) model adds to the idea of personal interest by placing value on an activity and emphasizing the importance of prior knowledge about a topic (Schunk et al., 2008). Attraction stems from high value for an activity and low prior knowledge. Interest can result from obtaining high value for an activity in combination with high prior knowledge. Comparatively, ignorance is from low value for an activity and low prior knowledge and noninterest comes from low value for an activity and high prior knowledge.

Hidi and Renninger (2006) conceptualized the development of interest into a four-phase model (Table 1). Each phase of interest is distinguished from the other phase based on affect, knowledge, and value. Also, the categories are based on one's own experience, temperament, and genetic predisposition toward an activity and can deviate depending on the person's effort, self-efficacy, and goal setting. The first phase is triggered situational interest and is characteristic of how an activity can attract a person's attention. It starts from an external factor, such as an exposure to a topic in areas that include activities such as group work and puzzles. Once there is a trigger for situational interest, there is a continual desire to keep exposing themselves to the topic.

The second phase is maintained situational interest, which is characterized by increased concentration on a topic. The reason attention is sustained in this phase is the person may develop feelings of value and importance towards that topic. Maintained situational interest, unlike triggered situational interest, is typically externally supported by a person's engagement in an activity related to the topic. A few ways that maintained situational interest can develop is through activities that are instructional such as project-based learning and cooperative learning. Having reached a maintained situational interest does not necessarily assure that it will develop into an individual interest.

Table 1

*Hidi and Renninger's (2006) Key Characteristics of the Four-Phases of Interest Development*

| Phase | Defining characteristics | Locus of Interest | Means of support |
|---|---|---|---|
| Triggered Situational | Catching one's attention; attraction | External | Puzzles, computer-adapted lessons, group work |
| Maintained Situational | Sustained attention via meaningfulness or personal involvement | External | Project-based learning, cooperative learning, one-on-one tutoring |
| Emerging Individual | Positive feelings towards, knowledge of, and value for a topic; self-generated curiosity | Internal | Learning is typically self-motivated but still requires instructional support from teachers & encouragement when confronted with difficulty |
| Well-developed Individual | Positive feelings towards, knowledge of, and value for a topic; self-generated curiosity (would we see "increased" knowledge here?) | Internal | Learning is typically self-motivated & is characterized by effortless learning, more advanced learning strategies, and perseverance when confronted with difficulty |

The third phase is emerging individual interest, which is marked by accumulated knowledge and the use of some meta-cognitive skills. Once in this phase, the topic is usually one that brings forth affirming emotions and value. Most of the thought processes at this phase include seeking out and acquiring information about the topic. Emerging personal interest does not infer that the person has developed these thoughts on their own; however, others could have introduced the topic to them, such as peers. This type of interest is maintained in instructional or learning settings where teachers can provide support when an individual is faced with adversity.

The fourth phase is a well-developed individual interest, which is characterized by perseverance in the face of adversity. This type of interest can bring about the same affirming emotions that the previous phase brought; however, individuals are more likely to engage themselves in the topic. It can happen when the individual is thinking about the topic in multiple ways, which results in the development of different thoughts, ideas, and questions. These can then motivate the person to learn more information about the topic. A well-developed individual interest can come from both external and internal support.

Hidi and Renninger's (2006) four-phase model of interest outlines the specific development of interest in different levels. This criterion is important when measuring interest because it allows one to acquire specific information. The different phases of interest are characterized by the information that comprises them, and each phase of interest encompasses positive emotions, value, knowledge, and meta-cognitive components. Therefore, each phase has certain characteristics that are easily categorized to determine which phase an individual may be experiencing.

Identifying the developmental phase of a child's interest necessitates developing and validating an interest measure. Self-report measures, such as questionnaires, have been the popular method for measuring interest in the past (Schunk et al., 2008). Such questionnaires have an individual respond to items that reflect a presence or absence of interest. Determining whether interest is present and the level of interest is an important foundation of the Project GEMS identification protocol because according to Hidi and Renninger's model interest is assumed to lead to high achievement. The lack of current interest measures in mathematics for use with elementary-age students that successfully assess or identify personal interest in mathematics is the impetus for this project.

*Assessing Interest in Mathematics*

It is important to develop a measure that distinguishes children with a high interest in math in order to select them for programs to further develop their interest and in turn, foster achievement. The current investigation focuses on the development of a math interest measure. The following inventories are the most frequently referenced math interest inventories identified that were deemed useful for this investigation. However, it is important note that these two highly used math scales are not intended for use with elementary aged children.

Lewis Aiken developed the Aiken's Mathematics Attitude Scale (Aiken, 1974), which addresses the issue of having an interest toward not only math problems, but also the process of math computations, numbers, and symbols themselves. This scale is intended for use with college-aged students. Inferences of how well a person may think of math as being useful and valuable as well as how much the person enjoys math are the identified goals. The Aiken's Mathematics Attitude Scale effectively addresses the

concepts of affect, experience, and value that are consistent with the four-phase model (Hidi & Renninger, 2006); however, this scale does not address the temporal aspect of attention, the amount of time spent engaging in math, willingness to problem solve, and independent perseverance in problem solving.

The Fennema-Sherman Mathematics Attitudes Scales (Duffy, Gunther, & Walters, 1997) is another scale that establishes interest, in regard to mathematics, and the most widely used scale to determine attitudes toward mathematics in high school populations. It contains categories assessing confidence, anxiety, value, enjoyment, motivation, and parent/teacher expectation (Duffy et al., 1997). This scale has been criticized for having inadequate reliability and validity for each of its nine scales including (a) Attitude Toward Success in Mathematics Scale, (b) Mathematics as a Male Domain Scale, (c) Mother Scale, (d) Father Scale, (e) Teacher Scale, (f) Confidence in Learning Mathematics Scale, (g) Mathematics Anxiety Scale, (h) Effectance Motivation Scale in Mathematics, and (i) Mathematics Usefulness Scale (Tapia & Marsh, 2004). Although the developers of the scale originally identified it as having nine scales, factor analytic findings do not support nine scales. Therefore, the Mathematics Attitude Scale cannot adequately determine what constructs are being measured. The Fennema-Sherman Mathematics Attitudes Scales addresses some of the four-phase model components including affect and value (Hidi & Renninger, 2006); however, it does not address one of knowledge, the major components of interest, which would be necessary to fulfill the four-phase model theory.

The review of these math interest inventories serves to provide background but does not significantly inform the current investigation. They conceptually do not meet all

of the components to address Hidi and Renninger's (2006) four-phase model of interest. As noted previously, these two mathematic scales were discussed based on their popularity and use among schools in the United States, however, they are not intended to be used for elementary aged children. Further, these scales are not support by a theoretical framework. These limitations support the need to develop a math interest inventory that is appropriate for use with an elementary-age population and whose development is guided from a contemporary theoretical model.

*Purpose*

The purpose of this project was to develop an elementary-aged self-report math interest inventory, based on a theoretical foundation, to meet one of the objectives of Project GEMS (Roberts, 2008). As noted in the review, there has been a problem with identifying gifted students from underrepresented and diverse populations. Project GEMS' (Roberts, 2008) will validate the use of teacher ratings, intellectual and academic assessments, and a measure of interest for use in the identification process. This identification process is designed to address the under identification of children from low-income backgrounds and minorities which results in underrepresentation of these groups in gifted programs. In order to implement this protocol interest inventories in the STEM areas are to be developed. The focus of this study will be the development of a math interest inventory. The concept of interest has been directly related to achievement, and Hidi and Renninger's (2006) four-phase model of interest serves as a theoretical foundation to inform and guide the development of the inventory. Previous math interest scales reviewed did not adequately address the Hidi and Renninger model and are not constructed for use with young children. Further, they lacked adequate psychometric

properties. Therefore, there is a need to develop a math interest inventory for use with elementary school aged children to use within Project GEMS' identification protocol.

The second purpose of this investigation is to pilot and field test the developed math interest measure to determine the measures' psychometric properties. Pilot testing was conducted with a group of elementary-aged students. The purpose of pilot testing was to refine the different items in the initial item pool. The purpose of field testing is to assess psychometric properties, including reliability and validity. Specifically, the following hypotheses were tested.

Hypothesis 1. The measure will evidence adequate internal consistency reliability ($r \geq .80$).

Hypothesis 2. Factor analysis will evidence a four-factor structure (Emotion, Value, Knowledge, Engagement) for the measure.

Hypothesis 3. There will be a significant and positive correlation between the Iowa Test of Basic Skills and the composite and subscales of the math interest inventory.

## Method

*Participants*

Six elementary schools from one south central Kentucky district participated in Project GEMS (Roberts, 2008) and comprised the participants for this investigation. A total of 1,429 students from six elementary schools completed the scale. There were 214 second grade students, 322 third grade students, 333 fourth grade students, 245 fifth grade students, and 315 sixth grade students. The sample consisted of 626 females, 718 males, and 85 who did not respond to the gender item. Since Project GEMS is targeting low-income populations, school selection was based on at least 50% of students at the school participating in the free and/or reduced lunch program. Currently, the percentage of students who participate in the gifted program and who receive a free or reduced lunch program are 1.5% in third grade, 4.4% in fourth grade, 7.5% in fifth grade, and 5.7% in sixth grade. Gifted students in the third through sixth grades are represented by only 1.9% of English Language Learners, 2.3% of African American students, and 1.2% of Hispanic students.

*Instruments*

*Math Interest Inventory.* A self-report measure developed for use in this investigation utilizes the concept of personal interest. Personal interest for this measure is defined as the last two phases of the four-phase model of interest development by Hidi and Renninger (2006). Each of the four-phases can be summarized and categorized with defining characteristics, locus of interest, and means of support (see Table 1). The phases assessed include emerging individual interest and well-developed individual interest, which are characterized by positive feelings, knowledge, value, and a self-generated

curiosity for the topic. Both phases also have an internal locus of control characterized by self-generated and self-motivated acquisition of information. Emerging individual interest is supported through the means of an educator who can provide the person interested with information as a way of persistent support when confronted with difficulties. Well-developed individual interest is usually characterized by those that seek out information by their own means by using personal skills to acquire the knowledge, and can endure on their own when difficulty arises.

Although Hidi and Renninger (2006) model their phases of interest into four categories, six potential states of interest can be identified if indifference and noninterest are included (Table 2). Indifference, or the lack of concern for a topic, is identified through the lack of positive emotions, value, knowledge, and a weak awareness. Noninterest would then lack positive emotions and value, but knowledge about the topic would be present, thus resulting in an unknown description of whether there is self-awareness.

Table 2

*Six Potential States of Interest*

| States of Interest | Positive Emotions | Value | Knowledge | Engagement |
|---|---|---|---|---|
| Indifference | Absent | Absent | Absent | Weak |
| Triggered situational | Present | Absent | Absent | Weak |
| Maintained situational | Present | Present | Absent | Weak |
| Emerging individual | Present | Present | Present | Moderate |
| Well-developed individual | Present | Present | Present | Strong |
| Noninterest | Absent | Absent | Present | Unknown |

A set of 27 questions were developed to assess interest consistent with Hidi and Renninger's (2006) model. Questions were grouped into four categories according to content including: Emotion, Value, Knowledge, and Engagement. Likert scale categories (never, rarely, sometimes, most of the time, and always) constituted the response options.

Participants for the three focus groups were chosen at one of the six schools to provide feedback on the Likert scaling and wording of items that were developed for the math interest inventory. Each group consisted of six participants and represented second, third, and fourth grades. Each group had two participants each who were teacher nominated as evidencing low, average, and high performing abilities.

Each participant was asked if they understood what the words meant in the Likert scale (e.g., rarely, sometimes), if they could differentiate between the different words (e.g., sometimes versus rarely), and their general preference for the choices. The

individual items on the interest measure were read to participants and then they were asked what the items meant. For example, participants were asked, "What do you think 'I am good at math' means?" This provided information about whether each question's intended meaning was consistent with the participants' understanding. Each question was read aloud to the participants and all comments were taken so that they could be compared after the meeting.

Based upon participant responses, modifications were made. One question was eliminated from the list (I help others with math homework) because it did not elicit a response from the participants that was useful. Two questions were added to the list including, "I talk to my family or friends about things I learned in math class" and "I try to do experiments at home that I learned about in math class." These questions were common topics that mentioned by the participants that were thought to be important. The situational specifiers of "in school" and "out of school" distinctions were eliminated so that the questions did not reflect a location. These questions were combined into one group. The final version has a total of 27 items representing the scales of emotion (seven items), value (five items), knowledge (five items), and engagement (12 items) (see Appendix B).

*Iowa Test of Basic Skills.* Participants were administered the Iowa Test of Basic Skills (ITBS) in May 2009 as a part of the existing school testing program. The ITBS is a group administered achievement test for students in kindergarten through eighth grade (Canivez, 2000). The purpose of the test is to assess school achievement in comparison to a nationally representative standardization sample. It assesses achievement with the following subtests: Vocabulary, Reading, Language Usage, Work Study, and

Mathematics. The mathematics section assesses math concepts and estimation, math problem solving and data interpretation, and math computation. The overall test-retest reliability coefficients range from .70 to .90, internal consistency and alternate forms reliability coefficients are between the .80 to .90 range, and the test also has adequate content validity (Canivez, 2000).

*Procedures*

The following procedures have been approved by the Institutional Research Board of Western Kentucky University (see Appendix C). Prior to the participants completing the interest measure, participants' parents were given an informed consent form. Once the informed consent was obtained from the parent, participants were asked for assent. The math interest measure was provided to the schools' curriculum coordinator, who directed the measure to the teachers. The teachers set up administration of the measure for the students. The participants were able to answer questions by completing a computerized version of the measure on a school computer. Teachers read the directions aloud to groups of participants in order for them to successfully and accurately answer the questions on the measure to the best of their ability.

## Results

Descriptive and statistics were obtained for the items from the interest measure, the scales and the total measure to gain further insight into the adequacy of the questions and the measure as a whole. First, descriptive statistics were calculated on all of the items. Second, internal consistency reliability (coefficient alpha) was evaluated on the hypothesized four- and five-factors and the overall scale. Third, a principal components and exploratory factor analysis was conducted on all of the items to determine factors. Fourth, items that may have contributed to problematic responses were addressed. Fifth, each item was analyzed with multiple criteria to assess whether individual items should be deleted or kept on the measure. Lastly, a correlation matrix between the math composite on the Iowa Test of Basic Skills and the interest inventory was computed.

Items 4, 6, 8, 10, 14, 18, and 20 were reversed and required reverse scoring scored prior to any analyses. Frequencies were obtained for every item and no impossible values were found. Next, descriptive statistics were computed (see Table 3). Examination of the descriptive statistics revealed that four items had skewness values of approximately 2 or greater (items 7, 8, 9, & 10). In addition, three items had means of 4.5 or higher (items 7, 8, & 10). These findings suggest a possibility of a social desirability response bias where participants might have chosen higher than normal scores because of the school environment.

Table 3

*Descriptive and Item-Analysis Statistics for the Math Interest Measure*

| Factor (coefficient alpha) | Item | Mean (SD) | Skewness | Item total correlation for each subscale | Alpha if item deleted for each subscale | Correlation with ITBS math |
|---|---|---|---|---|---|---|
| Emotion (0.893) | 1 | 3.849 (1.126) | -0.828 | .671 | .880 | .011 |
| | 2 | 4.021 (1.136) | -1.028 | .765 | .866 | .042 |
| | 3 | 3.890 (1.155) | -0.787 | .723 | .872 | -.059 |
| | 4 | 4.076 (1.191) | -1.202 | .713 | .874 | -.094** |
| | 5 | 3.819 (1.212) | -0.772 | .754 | .867 | -.081** |
| | 6 | 4.311 (1.133) | -1.624 | .651 | .883 | .026 |
| Value (0.712) | 7 | 4.631 (.898) | -2.696 | .542 | .643 | .053 |
| | 8 | 4.614 (.975) | -2.669 | .502 | .653 | .061* |
| | 9 | 4.429 (1.012) | -1.936 | .581 | .621 | .085** |
| | 10 | 4.557 (.992) | -2.384 | .521 | .646 | .032 |
| | 11 | 3.984 (1.408) | -1.171 | .311 | .763 | .212** |
| Knowledge (0.830) | 12 | 4.093 (.992) | -1.110 | .642 | .793 | .114** |
| | 13 | 4.018 (.961) | -0.998 | .727 | .770 | .129** |
| | 14 | 3.663 (1.070) | -0.470 | .509 | .832 | .091** |
| | 15 | 4.138 (.942) | -1.036 | .635 | .795 | .151** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 3.752 (1.056) | -0.635 | .647 | .791 | .084** |
| Engagement (0.842) | 17 | 3.711 (1.089) | -0.458 | .440 | .835 | .043 |
| | 18 | 3.594 (1.234) | -0.607 | .315 | .844 | .054 |
| | 19 | 3.835 (1.159) | -0.754 | .453 | .834 | .014 |
| | 20 | 3.653 (1.329) | -0.734 | .281 | .848 | .065* |
| | 21 | 3.294 (1.367) | -0.249 | .599 | .822 | -.114** |
| | 22 | 2.141 (1.276) | 0.880 | .581 | .824 | -.076* |
| | 23 | 2.459 (1.405) | 0.522 | .649 | .817 | -.062* |
| | 24 | 2.749 (1.455) | 0.225 | .605 | .821 | -.096** |
| | 25 | 2.412 (1.287) | 0.535 | .647 | .818 | -.147** |
| | 26 | 2.102 (1.283) | 0.951 | .548 | .826 | -.029 |
| | 27 | 3.176 (1.423) | -0.146 | .605 | .821 | -.070* |

*$p$ <. 05, two-tailed. **$p$ < .01 two-tailed.

Next, internal consistency reliability analyses were computed in order to test that the measure evidences adequate internal consistency. An overall reliability analysis resulted in a coefficient alpha estimate of .916. Cicchetti (1994) states that any instrument evidencing a coefficient alpha greater than .90 is considered appropriate for diagnostic purposes. Hypothesis 1, which predicted good reliability for the measure, was supported.

Additional internal consistency reliability analyses were obtained for each of the four hypothesized factors. The Emotion factor (items 1-6) had a coefficient alpha of

.893. The six items had item total correlations between .651 and .765. The coefficient alpha estimate did not improve upon deletion of any of the six items. The Value factor (items 7-11) had a coefficient alpha estimate of .712. Item total correlations ranged from .311 to .581. The coefficient alpha did improve to .763 with the deletion of item 11. The coefficient alpha estimate for the Knowledge factor (items 12-16) was .830. Item total correlations ranged from .509 to .727. The coefficient alpha estimate improved to .832 when item 14 was deleted. The Engagement factor (items 17-27) had a coefficient alpha estimate of .842. Item total correlations ranged from .281 to .649. The deletion of items 18 and 20 resulted in an increase in the coefficient alpha estimate to .848. When items 11, 14, 18, and 20 were deleted each scale also meets the internal consistency criterion of $r$ = .80. Hypothesis 1 was supported.

To address hypothesis 2, a principal components analysis was conducted initially on all 27 items. There were five components with eigenvalues greater than 1.0. Examination of the scree plot did not reveal a clean break past one to two components, with minor breaks between 4 to 5 and 5 to 6. Lautenschlager's (1989) parallel analysis criteria were also consulted for data consisting of 27 items with an N of approximately 1500. Acceptable eigenvalues were found for four factors, with the fifth factor failing to make the cutoff (actual value = 1.142, required value was 1.164).

An exploratory factor analysis with a maximum likelihood extraction and an oblimin rotation (because factors were expected to be related) was conducted for both the four- (see Table 4) and the five-factor (see Table 5) models. The Emotion factor fell out perfectly on the five-factor model but the four-factor model included additional items from the Value factor. Factor loadings from the pattern matrix ranged from .543 to .756

for the five-factor model and from .635 to .736 (items 1-6 only) for the four-factor model. Item 6 double loaded on the fourth factor on the five-factor model. The Value factor was split between factors four and five for the five-factor model with the addition of items 18 and 20. The four-factor model had all of the Value items load on to the Emotion factor and some Value items double loaded on the fourth factor (items 8 and 10). The Knowledge factor fell out reasonably well with the exception of additional items from the Engagement item pool. Factor loadings for the hypothesized items ranged from .519 to .794 for the five-factor model and from .568 to .815 for the four-factor model. Items loading on this factor from the Engagement item pool included items 17 and 19 in both analyses. However, the factor loading for these items were lower (five-factor model: item 17 = .379 and item 19 = .370; four-factor model: item 17 = .383 and item 19 = .394). The Engagement factor maintained its structure with some exceptions. Consistent items loading on the Engagement factor included items 21 through 27. Factor loadings for these items ranged from .502 to .784 for the five-factor model and from .510 to .788 for the four-factor model. Items from the Engagement item pool loading on other factors included items 17, 18, 19, and 20. These items were split between the Knowledge factor and the Value factor.

Table 4

*Pattern Matrix for Five-Factor Model for the Math Interest Measure: Factor Loadings*

| Item | Factor 1 (Emotion) | Factor 2 (Engagement Out of School) | Factor 3 (Knowledge) | Factor 4 (Engagement In School) | Factor 5 (Value) |
|---|---|---|---|---|---|
| 3 | .756 | | | | |
| 4 | .713 | | | .306 | |
| 5 | .705 | | | | |
| 2 | .687 | | | | |
| 1 | .574 | | | | |
| 6 | .543 | | | .414 | |
| 22 | | .784 | | | |
| 23 | | .784 | | | |
| 25 | | .725 | | | |
| 24 | | .719 | | | |
| 26 | | .679 | | | |
| 21 | | .519 | | | |
| 27 | | .502 | | | |
| 13 | | | .794 | | |
| 12 | | | .703 | | |
| 16 | | | .687 | | |
| 15 | | | .687 | | |
| 14 | | | .519 | | |
| 17 | | | .379 | | |
| 19 | | | .370 | | |
| 8 | | | | .483 | .359 |
| 10 | | | | .473 | .379 |
| 20 | | | | .462 | |
| 18 | | | | .418 | |
| 9 | | | | | .662 |
| 7 | | | | | .534 |
| 11 | | | | | .44 |

*Note.* Only loadings of ~.30 or greater were reported.

Table 5

*Pattern Matrix for Four-Factor Model for the Math Interest Measure: Factor Loadings*

| Item | Factor 1 (Emotion) | Factor 2 (Engagement) | Factor 3 (Knowledge) | Factor 4 (Value) |
|---|---|---|---|---|
| 3 | .736 | | | |
| 2 | .720 | | | |
| 5 | .713 | | | |
| 4 | .684 | | | |
| 1 | .655 | | | |
| 6 | .635 | | | |
| 10 | .560 | | | .396 |
| 9 | .541 | | | |
| 7 | .515 | | | |
| 8 | .515 | | | .405 |
| 11 | | | | |
| 22 | | .788 | | |
| 23 | | .787 | | |
| 25 | | .730 | | |
| 24 | | .720 | | |
| 26 | | .681 | | |
| 21 | | .522 | | |
| 27 | | .510 | | |
| 13 | | | -.815 | |
| 12 | | | -.721 | |
| 16 | | | -.721 | |
| 15 | | | -.699 | |
| 14 | | | -.568 | |
| 19 | | | -.394 | |
| 17 | | | -.383 | |
| 20 | | | | .429 |
| 18 | | | | .366 |

*Note*. Only loadings of ~.30 or greater were reported.

It is important to note that several schools reported that children were voicing concerns about two items, 6 and 8, during the administration of the measure. The word "hate" is included in item 6 and the word "stupid" in item 8. These are words that the children indicated were not to be used in school. This feedback should be considered when making decisions about which items to retain versus delete.

*Emotion Factor*

The items with the highest factor loadings for the Emotion factor were items 3, 4, 5, and 2. Items 4 and 6 loaded on both the Emotion factor and the Value factor. Item 4 and 5 negatively correlated with ITBS math scores. Item 6 for the Emotion factor contained the word "hate" which resulted in complaints from schools. Item 6 also exhibited a high level of skewness (-1.624). Based on these findings, items to be retained for the Emotion factor include 1, 2, 3, 4, and 5. Item 6 will be deleted due to double loading, lower factor loadings, contradictory correlation with math achievement, high degree of skewness, and problematic wording. A new coefficient alpha estimate was calculated for the five retained items, $r = .883$.

*Knowledge Factor*

None of the Knowledge items had problematic means or skewness values. If item 14 were deleted, then the internal consistency reliability estimate would increase slightly from .830 to .832. With regards to factor loadings, items 16, 13, 15, and 12 exhibited the highest loadings and none of these items double loaded across factors. Items 17 and 19 were deleted because they loaded onto the Knowledge factor for both the four- and five-factor model factor EFA. All of the items created for the Knowledge item pool were significantly correlated with ITBS math scores. The order of the magnitude of the

correlations from highest to lowest was 15, 13, 12, 14, and 16. Based on the data it was concluded that all five of these items should be retained which yields a reliability estimate for this subscale of .830.

*Engagement Factor*

None of the items from the Engagement factor had problematic means or skewness. Items 18 and 20 resulted in an improvement of coefficient alpha estimate to $r$ = .848. While items 21 through 27 did consistently load on the Engagement factor, this was not the case for the other items. Items 17 and 19 additionally loaded on the Knowledge factor as noted previous and items 18 and 20 loaded on the Value factor. Engagement items selected for inclusion in the final subscale included 21 through 27. Items 17, 18, 19, and 20 were omitted due to loading onto a different factor. Item 18 and 20 lowered the overall subscale reliability. Items 17 and 19 had substantially lower factor loadings than those for items 21 through 27. The revised coefficient alpha estimate calculated for the seven retained items (21-27) was $r$ = .863. In retrospect, it appears that the deleted items may require a higher level of metacognition and may be problematic for participants in elementary grades. In addition, it was concluded that a better name for this factor would be Engagement Outside of School. Hypothesis 2 was supported indicating that a four-factor model yielded better factor structure than the five-factor model.

*Value Factor*

The Value factor was the most problematic of the four factors. Three of the five items had means of 4.5 or higher (7, 8, & 10) as well as skewness values of 2.384 or higher. The five-factor model split the Value items into two factors. Items 7, 9, and 11 made up one factor (8 and 10 double loaded on this factor) and items 8 and 10 were part

of another factor that also included items 18 and 20. The four-factor model had all of the Value items load on the Emotion factor, while items 8 and 10 also double loaded onto the Engagement factor. Only three of the Value items correlated significantly with the ITBS math score, 11, 9, and 8. It is also important to remember that item 8 contained the word "stupid" which was voiced as a concern by the participants. It may be that this factor is being negatively impacted by items that double load on the Engagement factor. One potential approach is to re-run the factor analysis after superfluous items from the other scales have been discarded. An additional approach is to work on creating additional items to test for this factor.

*Re-Analysis*

After the elimination of problematic items (6, 8, 10, 17, 18, 19, and 20), a factor analysis was again conducted on the 20 items that evidenced reliability and adequate factor loadings (see Table 6). The Value factor was re-assessed by running an additional factor analysis with four factors consisting of all of the Value items except for items 8 and 10. Item 8 was deleted because of the language complaint from the schools and high mean/skewness. Item 10 was deleted because of a high mean/skewness, double loading on the four- and five-factor models, and because it was not correlated significantly with the ITBS math score. This re-analysis resulted in a much cleaner pattern matrix, especially for the Value items. All three of the items exhibited loadings of .471 or higher, exceeding the recommended .40 factor loading cutoff (Stevens, 2002). The new coefficient alpha estimate was .606 and item 11 was kept because it correlated the highest with the ITBS math section.

Table 6

*Factor Loading for the 20 Final Inclusion Items in the Math Interest Measure*

| Item | Factor 1 (Emotion) | Factor 2 (Engagement) | Factor 3 (Knowledge) | Factor 4 (Value) |
|---|---|---|---|---|
| 1. Math is interesting. | .589 | | | |
| 2. I like math. | .712 | | | |
| 3. Math is fun. | .747 | | | |
| 4. Math is boring. | .768 | | | |
| 5. Math is cool. | .700 | | | |
| 21. I talk to my family or friends about things I learned in math class. | | .508 | | |
| 22. I watch television shows about math. | | .788 | | |
| 23. I look at websites about math. | | .767 | | |
| 24. I play math computer games. | | .694 | | |
| 25. I read books about math. | | .723 | | |
| 26. I go places to learn about math. | | .691 | | |
| 27. I like to do math problems. | | .483 | | |
| 12. I know a lot about math. | | | .725 | |
| 13. I am good at math. | | | .840 | |
| 14. Math is hard for me. | | | .539 | |
| 15. I do well in my math classes. | | | .705 | |
| 16. Math is easy for me. | | | .695 | |
| 7. Learning about math is important. | | | | .538 |
| 9. Learning about math is helpful. | | | | .683 |
| 11. What I learn in math is useful. | | | | .471 |

*Note*. Only loadings of ~.30 or greater were reported.

Hypothesis 3 predicted that there would be a significant and positive correlation between the math composite score on the Iowa Test of Basic Skills and the interest inventory composite score. The overall composite score had a coefficient alpha estimate of .971. The correlation between the overall composite score and ITBS math scores was $r$ (1018) = -.010, $p$ = .371 (one tailed test). The correlations among the subscales, composite score, and ITBS math scores are reported in Table 7. All of the subscales significantly correlated with the ITBS math scores; however, two were negatively correlated (Emotion and Engagement). All of the subscales correlated with each other at magnitudes that would suggest that they are moderately related. Hypothesis 3 was partially supported, where Value and Knowledge subscales significantly and positively correlated with the Composite ITBS Math score.

Table 7

*Correlations Among the Interest Subscales, Composite Scores, and ITBS Math Scores*

| | Emotion | Value | Knowledge | Engagement | Composite |
|---|---|---|---|---|---|
| Emotion | | .458** | .548** | .516** | .839** |
| Value | | | .291** | -.238** | .532** |
| Knowledge | | | | .372** | .704** |
| Engagement | | | | | .829** |
| Composite | | | | | |
| ITBS Math | -.054* | .163** | .141** | -.107** | -0.010 |

*$p$ <.05, two- tailed. **$p$ < .01 two-tailed.

*Additional Recommendations*

Of the nine items deleted, six of them were negatively worded/reverse scored items. Only seven of the original 27 items were negatively worded. Consequently, future versions of this measure should mix up the order of questions to deter response acquiescence.

## Discussion

The purpose of this study was to develop, pilot, and field test a math interest self-report inventory based on theory: Hidi and Renninger's (2006) four-phase model of interest. Identifying students that are interested in mathematics at a young age is crucial because early identification can foster interest and develop achievement in the future. The need to develop a math interest measure was evident when a review of existing math interest inventories indicated they were atheoretical in design, designed for older populations, and did not evidence adequate psychometric properties. The development and field testing of a math interest measure fulfills one component of Project GEMS' (Roberts, 2008) identification protocol. The math interest measure is one piece of the overall identification protocol, which also includes teacher ratings, achievement, and non-verbal reasoning, where the overall goal is to increase the number of underrepresented students in math and science gifted programs.

Item analysis concluded that most items had acceptable variability, four items were highly skewed, and three items had higher than expected means. The overall internal consistency reliability of the interest measure was .916, which supports the first hypothesis that the items will evidence adequate internal consistency reliability and satisfy Cicchetti's (1994) criteria of significance. Item 11, "What I learn in math is useful," may have been problematic because of a social desirability response bias where students may have been compelled to respond to this question in a favorable way because teachers of the school administered the measure. All items on the math interest inventory evidenced adequate intercorrelations with the other items on the measure. An internal consistency analysis conducted for each factor (i.e., Emotion, Value, Knowledge, and

Engagement) evidenced coefficients with acceptable ranges for a screening measure. Evidence of the adequacy of a measure's reliability is important because it provides evidence of consistency in measurement and serves as a foundation for exploring other psychometric properties.

There was an overall problem with some of the negative words (e.g. hate) that were included in the original item pool. These words created reactance from the students as they are taught these words are inappropriate for use in the schools. The test items containing the negative words should be revised and the measure administered with the revised items to determine if there is a difference in responding. The Value factor only had three items after the reliability analysis revisions. Increasing the number of items for the Value factor may increase the overall reliability coefficient for that factor.

The purpose of the study was to develop an interest measure that reflects Hidi and Renninger's (2006) four-phase model of interest. Four- and five- factor models were tested with an exploratory factor analysis. The five-factor model split the Engagement category into two separate factors, in school and out of school engagement. One explanation for why the in and out of school engagement categories emerged could be because students can differentiate when they are told what to do while in school compared to when they are out of school and given a choice. However, the principal components analysis using Lautenschlager's (1989) parallel analysis criteria determined that only the four-factor model could be substantiated. After analyzing the data, most of the in school engagement items were deleted and the resulting items were combined into the overall Engagement factor. These four components coincide with Hidi and Renninger's (2006) idea of specific factors that should be present for personal interest to

be evidenced. This result supports that the math interest measure is consistent with the four-phase model of interest, supporting hypothesis 2. Aiken's Mathematic Attitude Scale (1974) and the Fennema-Sherman Mathematics Attitudes Scales (Duffy, et al., 1997) do not adequately meet the criteria of Hidi and Renninger's (2006) four phase model of interest. Further, the Fennema-Sherman Mathematics Attitude Scales did not meet the criteria for successful identification of factors.

The ITBS overall composite achievement score was correlated with the participants composite and subscale scores from the interest inventory, which provided a means for assessing the scale's construct validity. In order to support hypothesis three, this correlation needed to be significant and positive, meaning that high achieving math students would display a high math interest. This hypothesis was not supported because the scores on the math achievement scale of the ITBS do not correlate sufficiently with the developed math interest measure. The ITBS overall score correlation with the composite interest inventory was -.010. This relationship was neither significant nor positive. One explanation for this finding is that students may have high interest in math but do not perform well on standardized achievement tests. Most of the subscales of the math interest scale evidenced positive but small correlations with the ITBS math score; however, Emotion and Engagement were negatively correlated.

In interpreting the present results, readers should consider some limitations. The premise behind the interest measure was to help identify students from underrepresented and diverse populations that are interested in math. Although the elementary schools chosen for the project evidenced a high proportion of students from low socioeconomic backgrounds, the exact breakdown for the sample is unknown. In addition, the schools

were not representative of the nation in regards to ethnic diversity. One suggestion is to administer the math interest measure to a more diverse population and compare the results with the current results.

The third hypothesis proposed is that there should be a significant and positive correlation between the math composite score on the ITBS and the overall and subscale scores on the math interest inventory. Although all of the subscale correlations were significant, they were small. One explanation for the small correlations is that the tests were measuring two different constructs (achievement and interest). It would be reasonable to suggest that although interest and achievement may share similar qualities, the two tests are not measuring the same construct.

The data did not fully support the third hypothesis stating that there would be significant and positive correlations between the scores on the ITBS and the scores on the math interest inventory. Two of the four subscales, Emotion and Engagement, were negatively correlated. Additionally, a longitudinal study would provide evidence of the measure's predictive validity. Individuals will be examined over time to determine if those identified with high interest will result in having high achievement in math. This would provide additional support that interest and achievement are correlated and that interest can predict achievement over time.

The developed math interest inventory is a self-report measure, and all self-report measures inherently have many drawbacks. There may be a social desirability response bias where participants may respond with a culturally appropriate answer, instead of their true feelings. Another limitation to self-report measures is that participants may over generalize their responses. For example, when an item asks, "Math is easy for me," a

student may respond with the exaggerated response of "never" although they may not have problems with all math concepts.

A common solution to self-report biases begins with the introduction of the measure to the participants. Although there is a brief explanation about the directions of completing the measure, explaining to the students ahead of time that the results will not impact their grades or perceptions of them as students may help to alleviate the social desirability response bias of them wanting to respond in a positive manner. Without the presence of pressured feelings to conform, students may respond differently. The combination of the prior suggestions should help with the self-report biases as well as the overall results to the research.

The goals of this project were to create and refine items for an interest inventory based on Hidi and Renninger's (2006) four-phase model of interest and to be used within an identification protocol for Project GEMS. These goals were obtained as well as supporting hypothesis one and two. The third hypothesis, which addressed the issue of construct validity, was partially supported. The lack of a significant correlation between the ITBS math achievement score and the total math interest score is problematic as any measure needs to evidence adequate validity to support its use. However, the interest measure did reflect factor structure validity. The development of an interest measure is one proposed grant outcome for Project GEMS (Roberts, 2008). The current investigation satisfies the development of a math interest measure for elementary-aged children based on a theoretical model of interest. The math interest measure evidences scale and total score internal consistency and a factor structure consistent with the theoretical model on which it was based. In the future, the interest measure could possibly serve as a way to

identify individuals for the identification of students from underrepresented populations who may become highly gifted in mathematics if given the opportunity to develop their interests. The possibility that there are different ways to assess and identify students from underrepresented populations that are usually not involved in gifted programs could change the identification process for gifted programs in the public schools and serve more diverse populations in these programs. Ultimately, such outcomes would help to facilitate the talents of all children and benefit society as a whole by producing a higher number of individuals with high proficiency in mathematics, which in turn impacts the number of students entering careers that build on a high achievement in the area of mathematics such as the sciences, engineering and technology.

References

Aiken, L. (1974). Two scales of attitude toward math. *Journal for Research in Mathematics Education, 5*(2), 67-71.

Baldwin, A. (2005). Identification concerns and promises for gifted students of diverse populations. *Theory Into Practice, 44*(2), 105-114.

Callahan, C. (2005). Identifying gifted students from underrepresented populations. *Theory Into Practice, 44*(2), 98-104.

Canivez, G. (2000). Predictive and construct validity of the developing Cognitive Abilities Test: Relations with the Iowa Test of Basic Skills. *Psychology in the Schools, 37*(2), 107-113.

Chan, D. (2000). Identifying gifted and talented students in Hong Kong. *Roeper Review, 22*(2), 88-93.

Cicchetti, D. (1994). Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. *Psychological Assessment, 6*(4), 284-290.

Duffy, J., Gunter, G., & Walters, L. (1997). Gender and mathematical problem solving. *Sex Roles, 37*(7-8), 477-494.

Hidi, S., & Renninger, K. (2006). The four-phase model of interest development. *Educational Psychologist, 41*(2), 111-127.

Kornhaber, M. (1999). Enhancing equity in gifted education: A framework for examining assessments drawing on the theory of multiple intelligences. *High Ability Studies*, *10*(2), 143-160.

Krapp, A., Renninger, K. A., & Hidi, S. (1992). The role of interest in learning and development. *Applied Cognitive Psychology, 8*(5), 526-528.

Kronholz, J. (2004). Economic time bomb: U.S. teens are among the worst at math. *The Wall Street Journal Online*. Retrieved March 16, 2009, from http://online.wsj.com/.

Lautenschlager, G. J. (1989). A comparison of alternatives to conducting Monte Carlo analyses for determining parallel analysis criteria. *Multivariate Behavioral Research, 24,* 365-395.

Merriam-Webster Dictionary. (2010*). Definition and more from the Free Merriam-Webster Dictionary*. Retrieved April 11, 2010, from http://www.merriem-webster.com/dictionary/interest.

National Association for Gifted Children. (2009). *Gifted among underserved and disadvantaged populations*. Retrieved September 18, 2009, from http://www.nagc.org.

National Association for Gifted Children. (2011). *Jacob Javits Gifted and Talented Students Education Act.* Retrieved March 15, 2011, from http://www.nagc.org/index.aspx?id=572.

National Center for Education Statistics. (2007). *Trends in international mathematics and science study (TIMSS)*. Retrieved April 4, 2009, from http://nces.ed.gov/.

Renzulli, J. S. (1978). What makes giftedness? Reexamining a definition. *Phi Delta Kappan, 60*(3)*,* 180-184.

Renzulli, J. S., Smith, L. H., White, A. J. Callahan, C. M., & Hartman, R. K. (1976) *Scales for Rating the Behavioral Characteristics of Superior* Students. Mansfield Center, CT: Creative Learning Press

Roberts, J. (2008). *Project GEMS (gifted education in math and science)*. Unpublished manuscript, Western Kentucky University: Bowling Green, Kentucky.

Saraouphim, K. (1999). DISCOVER: A promising alternative assessment for the identification of gifted minorities. *Gifted Child Quarterly, 43*(4), 244-251.

Schunk, D., Pintrich, D., & Meece, J. (2008). *Motivation in education: Theory, research and applications* (3rd ed.). Upper Saddle River, NJ: Pearson.

Stevens, J. P. (2002). *Applied multivariate statistics for the social sciences (4th ed.)*. Hillsdale, NJ: Erlbaum.

Tapia, M, & Marsh, G. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly, 8*(2), *16-21.*

U.S. Department of Education. (2010). *No Child Left Behind policy*. Retrieved April 6, 2010, from http://ed.gov/nclb/landing.jhtml.

Appendix A

Math Interest Measure (27 items)

First name Last name

School (drop down)

Grade (drop down)

Please answer the questions below. Honestly, there are no right or wrong answers.

| | Never | Rarely | Sometimes | Most of the time | Always |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1. Math is interesting. | | | | | |
| 2. I like math. | | | | | |
| 3. Math is fun. | | | | | |
| 4. Math is boring. | | | | | |
| 5. Math is cool. | | | | | |
| 6. I hate math. | | | | | |
| 7. Learning about math is important. | | | | | |
| 8. Learning about math is stupid. | | | | | |
| 9. Learning about math is helpful. | | | | | |
| 10. Learning about math is a waste of time. | | | | | |
| 11. What I learn in math is useful. | | | | | |
| 12. I know a lot about math. | | | | | |
| 13. I am good at math. | | | | | |
| 14. Math is hard for me. | | | | | |
| 15. I do well in my math classes. | | | | | |
| 16. Math is easy for me. | | | | | |
| 17. I answer lots of questions in my math class. | | | | | |

18. I get distracted easily during math class.

19. It is easy for me to pay attention in math class

20. I think about other things a lot during math class.

21. I talk to my family or friends about things I learned in math class.

22. I watch television shows about math outside of school.

23. I look at websites about math outside of school.

24. I play math computer games outside of school.

25. I read books about math outside of school.

26. I go places to learn about math outside of school.

27. I like to do math problems outside of school.

Appendix B

Revised Math Interest Measure (20 items)

First name Last name

School (drop down)

Grade (drop down)

Please answer the questions below. Honestly, there are no right or wrong answers.

| | Never | Rarely | Sometimes | Most of the time | Always |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1. Math is interesting. | | | | | |
| 2. I like math. | | | | | |
| 3. Math is fun. | | | | | |
| 4. Math is boring. | | | | | |
| 5. Math is cool. | | | | | |
| 6. Learning about math is important. | | | | | |
| 7. Learning about math is helpful. | | | | | |
| 8. What I learn in math is useful. | | | | | |
| 9. I know a lot about math. | | | | | |
| 10. I am good at math. | | | | | |
| 11. Math is hard for me. | | | | | |
| 12. I do well in my math classes. | | | | | |
| 13. Math is easy for me. | | | | | |
| 14. I talk to my family or friends about things I learned in math class. | | | | | |
| 15. I watch television shows about math outside of school. | | | | | |
| 16. I look at websites about math outside of school. | | | | | |

17. I play math computer games outside of school.

18. I read books about math outside of school.

19. I go places to learn about math outside of school.

20. I like to do math problems outside of school.

Appendix C

Humans Subject Review Board Approval Letter

WKU

A LEADING AMERICAN UNIVERSITY WITH INTERNATIONAL REACH

HUMAN SUBJECTS REVIEW BOARD

In future correspondence, please refer to HS10-042, September 18, 2009

Dr. Steve Wininger
Psychology
WKU

Dr. Steve Wininger:

Your revision to the research project, *GEMS Teacher Instrument Development*, was reviewed by the HSRB and it has been determined that risks to subjects are: (1) minimized and reasonable; and that (2) research procedures are consistent with a sound research design and do not expose the subjects to unnecessary risk. Reviewers determined that: (1) benefits to subjects are considered along with the importance of the topic and that outcomes are reasonable; (2) selection of subjects is equitable; and (3) the purposes of the research and the research setting is amenable to subjects' welfare and producing desired outcomes; that indications of coercion or prejudice are absent, and that participation is clearly voluntary.

1. In addition, the IRB found that you need to orient participants as follows: (1) signed informed consent is not required; (2) Provision is made for collecting, using and storing data in a manner that protects the safety and privacy of the subjects and the confidentiality of the data. (3) Appropriate safeguards are included to protect the rights and welfare of the subjects.

**This project is therefore approved at the Expedited Review Level until September 18, 2010.**

2. Please note that the institution is not responsible for any actions regarding this protocol before approval. If you expand the project at a later date to use other instruments please re-apply. Copies of your request for human subjects review, your application, and this approval, are maintained in the Office of Sponsored Programs at the above address. Please report any changes to this approved protocol to this office. A Continuing Review protocol will be sent to you in the future to determine the status of the project. Also, please use the stamped approval forms to assure participants of compliance with The Office of Human Research Protections regulations.

Sincerely,

Paul J. Mooney, M.S.T.M.
Compliance Coordinator
Office of Sponsored Programs
Western Kentucky University

HUMAN SUBJECTS REVIEW BOARD WKU APPROVED

HSRB APPLICATION # 10-042
APPROVED 9/18/09 to 9/18/10
EXEMPT EXPEDITED FULL BOARD
DATE APPROVED 9/18/09

cc: HS file number Wininger HS10-042


Office of Sponsored Programs | Western Kentucky University | 1906 College Heights Blvd. #11026 | Bowling Green, KY 42101-1026
**phone:** 270.745.4652 | **fax:** 270.745.4211 | **e-mail:** paul.mooney@wku.edu | **web:** http://orsd.wku.edu/Research_Compliance/Human_Subjects/