5-2013

The Effects of Gender and Implicit Theories on Science Achievement and Interest in Elementary-Aged Students

Savannah Benningfield
Western Kentucky University, savannah.breeding902@topper.wku.edu

THE EFFECTS OF GENDER AND IMPLICIT THEORIES ON SCIENCE ACHIEVEMENT AND INTEREST IN ELEMENTARY-AGED STUDENTS

A Thesis
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
Savannah Benningfield

May 2013

THE EFFECTS OF GENDER AND IMPLICIT THEORIES ON SCIENCE ACHIEVEMENT AND INTEREST IN ELEMENTARY-AGED STUDENTS

Date Recommended April 24th, 2013

Steven R. Wininger, Ph.D.
Director of Specialist Project

Carl Myers, Ph.D.

Qin Zhao, Ph.D.

5-10-13

Dean, Graduate Studies and Research Date

ACKNOWLEDGMENTS

I would first like to thank my thesis chair, Dr. Steven Wininger, for your guidance and support. You have taught me so much and working with you has been a sincere pleasure. Thank you as well to my committee members, Dr. Carl Myers and Dr. Qin Zhao, for all of your hard work. Your insights, direction and encouragement have been paramount to this project. I would also like to extend thanks to Dr. Julia Roberts and Dr. Tracy Inman. My time working with you at The Center for Gifted Studies has certainly helped to shape who I am and want to be as a professional. To my parents, David Breeding and Vanessa Cox, thank you for your unending encouragement and loving example. I would not be who I am without either of you. To the Shepperd and Nichols families, thank you for the nudge in the right direction. I would also like to thank the wonderful women in my cohort. I could not have successfully completed this journey without all of you. I extend thanks to all of my friends and extended family who have supported my endeavors. To my husband, Andrew Benningfield, I cannot put into words what you mean to me. Thank you for making the good days great and the bad days bearable. Your unwavering love and support astound me. Finally, thank you to my Lord and Savior, Jesus Christ. It is through You that I can do all things.

TABLE OF CONTENTS

LIST OF TABLES

THE EFFECTS OF GENDER AND IMPLICIT THEORIES ON SCIENCE ACHIEVEMENT AND INTERST IN ELEMENTARY-AGED STUDENTS

Savannah Benningfield May 2013 40 Pages

Directed by: Dr. Steven R. Wininger, Dr. Carl Myers, Dr. Qin Zhao

Department of Psychology Western Kentucky University

The current study set out to determine the relationship between student grade level, implicit views of science ability, science achievement and science interest. Differences by grade level were also explored. The study also considered the differences in male and female implicit theories of science ability, science interest, and science achievement. Participants in the current study consisted of a total of 1910 students from six elementary schools from one south-central Kentucky district that participate in Project GEMS (Gifted Education in Math and Science). Data were analyzed by means of analysis of variance and Pearson correlations. Younger students evidenced lower scores on the implicit theories measure. No gender differences were observed in implicit theories of science ability or science interest. Females did evidence lower achievement in science than males. Implicit theories of science ability were significantly and positively correlated with science achievement. Conversely, no such relationship existed between implicit theories of science ability and interest. Limitations of the current study are discussed and possible future directions are offered. Findings from the current study underscore the importance of considering domain-specific views of ability when addressing poor science performance and when considering gender gaps in science achievement.

Introduction

Science education in the U.S. has been an area under much scrutiny since reports of world-wide science achievement levels were first published. Assessments of science achievement, conducted in 1988 by the Educational Testing Service, included participation of 24,000 students from Ireland, Korea, Spain, the United States, the United Kingdom, and four Canadian provinces. The Canadian provinces included French and English populations each from Ontario, Quebec, and New Brunswick as well as a population from the British Columbia for a total of 12 student populations. A report on the assessment results by Lapointe, Mead, and Phillips (1989) stated that the United States ranked lowest in math proficiency and ninth of the 12 international student populations in science proficiency. According to statistics reported in 2000, the U.S. made a slight improvement in the 12 years that had passed. Of the 28 countries who participated in the research, the United States ranked at number 14 (Holden, 2000). Lapointe et al. reported that girls ranked lower than boys in every area of science achievement measured. The difference was statistically significant in all populations except the United Kingdom and the United States. Gender gaps in achievement were much greater in science than in mathematics overall. This pervasive gender gap is the main focus of this thesis project.

Women are vastly underrepresented in science, technology, engineering, and math (STEM) careers in the United States (Hill, Corbett, & St. Rose, 2010). Gender differences with regard to interest and achievement in these subject areas are also prevalent in school-aged children. Freedman-Doan et al. (2000) asked students to rank school subjects from what they believed they were best at to worst. This study found that girls were much less apt to rate themselves at being best at science or math compared to boys. Though no specific cause is agreed upon in the literature, a meta-analysis of the national differences between girls and boys in school determined that a national policy aimed at changing stereotypes of women in science as well as decreasing the sex gap in science engagement would best serve women in terms of achievement in science (Nosek et al., 2009).

The knowledge base of the achievement gap in girls and boys is ever growing; however, a causal mechanism for this gap is still unknown. One possible explanation may be found by researching the views of students on intelligence based on Carol Dweck's (2006) implicit theories. Her theory states that people's beliefs about personal characteristics can be mapped onto a continuum between entity and incremental mindsets, which mean that the person either thinks that his or her abilities are determined by the intelligence with which they are born and that it cannot be changed or that one can improve abilities by working to increase intelligence, which is malleable.

The purpose of this thesis project is to determine the effects of gender and implicit theories on science interest and achievement in second to sixth grade students. The following sections will provide information from relevant research on the topics of science achievement, science interest, and implicit theories.

Literature Review

Science Achievement

Research concerning gender differences in science achievement is mixed with regard to the magnitude of difference; some researchers have found strong support of gender differences (e.g., Nosek et al., 2009), others have found decreasing gender differences (e.g., Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002) and still others have reported nonsignificant to no difference in achievement by gender (e.g., Hyde & Linn, 2006). While research supporting gender differences in science achievement has shown that boys often outperform girls in science areas, some studies have found converse results; that girls outperform boys when comparing grades obtained in science classes (Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005). Reasons for the disparities within the research are currently unknown but the implications are important nevertheless.

The studies reviewed for gender differences all utilize self-evaluation techniques and are typically done on a Likert-type scale as is typical for studies in psychology (Leonardelli, Hermann, Lynch, & Arkin, 2003). One study simply asked students in first, second, and fourth grades to rate themselves by asking, "What am I best at?" and to then put subjects and activities in rank order by the child's perception of their ability (Freedman-Doan et al., 2000). Multiple other studies followed this format of asking open-ended questions of students and coding the responses.

A meta-analysis by Hyde and Linn (2006) evaluated prior research and disputed the relevancy of the finding that there were gender differences in relation to science achievement. Hyde and Linn reported that a slight difference between girls and boys remains stable from 4th to 12th grade and that this difference was not clinically significant though the results reported were statistically significant. The authors argued that effect size of $d = 0.11$ is more supportive of gender similarities than differences. They further state that reporting gender differences only serves to reinforce the stereotype that girls are less capable than boys in science as well as math. They suggested using mathematics and science achievement scores in middle and high school to better assess where differences might lie in reality and how to better intervene for struggling students. The study by Freedman-Doan et al. (2000) found similar results in that girls were much less apt to rate themselves at being best at science or math than boys. Girls did, however, rate themselves as being best at reading more than the researchers anticipated. These findings support societal assumptions that girls are not as good at math and science as boys but are excellent readers when compared to boys.

One possible explanation for gender differences in science achievement lies in gender differences in views of intelligence. A study conducted by Jacobs et al. (2002) as part of the Childhood and Beyond longitudinal project determined that there are differences in competence beliefs by gender for children in first to twelfth grades. These differences were determined to be largest in young children (first to fourth grades) and the differences were found to decrease or remain stable over time based on competency areas (math, language arts, and sport competencies). Additionally, the authors reported that there is a trend demonstrating growing similarities in boys and girls in relation to their ideas about intelligence. The study was conducted by sampling students attending school between the years of 1989-1999. A cross-sectional design was also used for three cohorts across elementary, middle, and high school years. The students were in the first, second, and fourth grades during year one and were in grades 9, 10, and 12 during the final year of data collection. The competence belief items administered to the students were based on children's beliefs about math, language arts and sports domains as assessed by previous researchers. The items themselves were constructed based on factor analyses and theoretical considerations. The authors in this study also stated that achievement levels are related to the beliefs that students hold about their intelligence.

Science Interest

In addition to research on gender differences in science achievement, student interest in science has also been studied. Research has indicated that students who are interested in the subject they are studying, including science, focus more attention and concentration as well as persistence on the subject (Winne & Nesbit, 2010). Ainley et al. argued that as a result, students often learn more about the subjects in which they are interested (as cited in Winne & Nesbit, 2010). Large gender differences in science interest have been identified as well. Research conducted by Miller, Blessing, and Schwartz (2006) studied the science perceptions of 79 high school students. The researchers addressed the students' perceptions of their science classes, scientists and science in general as well as future plans to major in science. The results of this study concluded that overall, girls found science unappealing compared to boys, although 13 of the 39 females planned to major in science. Most of the girls who planned to major in a science (11 of the 13) were doing so in preparation for a person- or animal-centered medical career. These findings are in support of past research by Astin (1975) who recruited boys and girls in regular education seventh to ninth grades who participated in a science or math contest and assessment. Those students chose to enter in either a math or science competition and could then choose to take a math or science aptitude assessment, or both, as part of another competition. The tests that the students completed included a section on occupational plans. Girls ranked investigative (science research worker), social (social science teacher), and artistic (poet) occupations among their highest choices and boys ranked investigative (scientific research worker) occupations as their highest choice by a large percentage. Though scientific careers (investigative) were ranked highly by both girls and boys, 33% of girls compared to 54% of boys rated investigative careers as an occupation they would enjoy. According to this research, girls are much less interested in science careers than boys. In addition, early interest in science is cited as a possible factor in higher achievement and science career choice for boys.

Zuckerman, Gagne, and Nafshi (2001) studied the hypotheses that academic interests are malleable, or can be changed. This study included undergraduate students who had declared a major. The participants were asked to fill out questionnaires that assessed the students' commitment to their major, interest, and competence in their major. Students also filled out questionnaires assessing entity and incremental mindsets of interest held by the students. The researchers found that those students who believed they were not doing well in their major and held an entity view of their major, which is that their interests would not change, were more likely than any other group to change their major. The researchers hypothesized that those who changed their major did so due to a poor match of interests and academic studies. Those students who did well in their major and were interested in the subject were least likely to change their major. These results are important because they suggest that the gender differences in science interests may diminish if girls are engaged in the topic and have confidence in their abilities to do well.

One study set out to determine if increasing girls' interest in physics did in fact help contribute to greater achievement scores (Häussler & Hoffmann, 2002). The study focused on seventh grade physics. Six schools with two sections of physics each participated in the intervention program. An additional seven classes served as the control groups. The intervention involved adapting the curriculum to include topics of interest for girls, training teachers to support the development of physics related self-concept in girls, splitting the class in half every other lesson, and teaching boys and girls separately every other lesson. To track the effectiveness of the program, an interest survey was given to all students at the beginning and end of the program. The greatest loss of interest occurred for boys in the control groups followed by girls in the control group. There was not a significant loss of interest for either boys or girls in the classes that were segregated by gender. Girls also demonstrated the most gains in physics related self-concept in classes that were segregated. The greatest gains in cognitive ability and achievement for girls were made in the segregated classrooms as well. At the end of the intervention, girls' achievement scores were higher than the boys in any condition. These results are important in that they support the notion that girls and boys have the potential to achieve equally well when interest in the subject is high.

Implicit Theories

Carol Dweck's implicit theories were developed as an explanation for the differing achievement levels, motivation, and goal setting in students with otherwise equal academic ability. Dweck emphasizes that students hold different appraisals of the changeability of intelligence. Individuals who hold an entity view of intelligence believe that intelligence is a nonmalleable trait and thus cannot be changed. Students with an incremental view of intelligence believe that with continued practice intelligence can be further developed. The view held by the student influences how the student reacts to academic tasks. The child with an entity view will avoid tasks that are difficult and that the child feels is beyond his or her ability. The child with an incremental view will assess tasks that are difficult as a challenge but, more importantly, as an opportunity to develop new skills (Blackwell, Trzesniewski, & Dweck, 2007).

As research has continued to be conducted surrounding this theory, many interesting findings have surfaced regarding the differences among those with an incremental versus entity view. Hong, Chiu, Dweck, Lin, and Wan (1999) found in their research that not only did the study participants with differing mindsets attribute their successes and failures to their belief of having adaptable or fixed intelligence, but the goals which those in each category set are different in nature. For this particular study the participants were undergraduate students from either the United States or Hong Kong. Researchers surmised that incremental theorists focused on learning goals or those meant to increase ability. Those who held an entity view focused on performance goals or those meant to demonstrate ability while avoiding tasks that would demonstrate failure. Another major difference was that the goals set by incremental theorists were intended to offer practice or the opportunity to learn something new while entity theorists did not focus on learning anything new.

Research shows that those who hold an entity view of intelligence believe that although one can always learn new things, one’s intelligence cannot be changed. This belief offers the entity focused individual an explanation for failure (Heyman & Dweck, 1998). In general, this explanation functions as a defense mechanism; an entity focused individual who achieves goals attributes success to their abilities and intelligence. Conversely, this same individual attributes failure to complete such a task to their limited and unchanging ability or intelligence. The person with an incremental mindset of intelligence attributes success to practice and a developed skill set. Failure for this person is due to inexperience or lack of effort. The incremental theorist would simply argue that with more practice he or she could successfully complete the task (Kurtz-Costes, McCall, Kinlaw, Wiesen, & Joyner, 2005).

Incremental and entity views of intelligence also relate to achievement, though research on this topic is mixed. In a study published by Jacobs et al. (2002), 761 children in first through twelfth grades were studied for changes in self-belief. Data were collected over the course of six years. The authors cite research by multiple authors that supports the notion that one's beliefs about self-competence are related to achievement, "…even after controlling for previous achievement or ability in a variety of domains" (p. 509). This suggests that holding the view that one cannot improve will hinder achievement and that the inverse is also true. Other research by Ablard and Mills (1996) stated that implicit theories are unrelated to ability but that implicit theories do impact behavior in academic settings, which accounts for any difference in achievement. This research was conducted by studying third through eleventh grade students who were identified as academically gifted based on scores in the 97^{th} percentile or above on standardized achievement tests at the students' grade level in addition to scores in the 70^{th} percentile or above when compared to norms two to five levels above the students' grade level at the time of testing. The students rated their beliefs on intelligence stability, how hard they work in school, and their interest in difficult tasks. This research supports other findings that implicit theories do not directly affect achievement but rather the motivation a person has to succeed. This finding is based on nonsignificant correlations between implicit theories and achievement except when mediated by motivational factors (Blackwell et al., 2007).

It is important to note that views on intelligence, including implicit theories, are not inherently dichotomous but rather a continuum of views that are likely to change slightly with maturity or situational occurrences in life. Research by Kurtz-Costes et al. (2005) found that children are especially subject to changing views of intelligence and abilities globally as evidenced by data collected from students in kindergarten, second, fifth, and eighth grades. Though the degree to which change occurs may not be constant across published research, one constant has been agreed upon; children are more likely to hold a primarily incremental view of intelligence at an early age (kindergarten through second grade) and shift slightly through young adolescence to hold more of an entity view of intelligence (fifth grade and beyond). Researchers found that not only do children shift their overall assessment of intelligence from incremental to entity, they also alter what attributes define intelligence. For example, in this study, first grade children perceived children who were nicer and could jump higher than others as more intelligent. They were also very optimistic that they could increase their own intelligence. By the fifth grade, students not only began to evidence a more fixed view of intelligence but also stated that the more effort a task required the less capable a person would be of completing that task. In other words, though many people can perform particular task, those who expend the most effort are the least skilled in that area.

Further research suggests that not only do children’s views of the malleability of intelligence change with maturity, but perhaps that the school environment also serves as an impetus for the change. Children receive feedback from school for behavioral, academic, and emotional conduct. As children get older and progress through school the type of assessment and feedback changes. Kärkkäinen, Räty, and Kasanen (2008) argue that when children are young (preschool to third grade), they are focused more on their abilities in terms of what they think they can do well, and as children age their focus shifts to what they can well do in relation to others. This was evidenced based on standardized open-ended interviews conducted with the children by Stipek and Tannatt (as cited in Kärkkäinen et al., 2008). The researchers of this study call this shift *comparative feedback*. Children in kindergarten are likely to respond differently if you ask about an activity they can do well than if you ask the same question in the third grade. For example, when asked if he likes to run, a kindergartner might respond that he can run fast. By the third grade the same child is likely to respond that he enjoys running but is not the fastest in his class. By the time the student is in the fifth grade, he will not only compare his interests in activities to others in his class but his academic merits and is more likely to feel that his abilities are based on a fixed intelligence that he cannot change.

Leondari and Gialamas (2002) also support the finding that elementary school-aged students are more likely to hold an incremental view of intelligence than high school-aged students as evidenced by student responses to questionnaires. However, while research demonstrates that adults are more likely to hold an entity view of abilities, Garcia-Cepero and McCoach (2008) found in their research that some educators (no general tendency indicated) are more likely to hold an incremental view and foster this view in their students. Those educators were identified based on the attributes with which they associated intelligence. The teachers who included inter- and intrapersonal skills and practical abilities as components of intelligence were more likely to hold an incremental view of intelligence and promote that view in their classrooms. The research did not address whether or how the view of the teacher affected the views of the students in the classroom.

There has also been some debate as to the presence of gender differences in implicit theories. Ablard and Mills (1996) reported in their study of implicit theories of intelligence that they found no significant gender differences despite prior research that stated otherwise. This experiment studied gifted students in third through eleventh grades. What was interesting to note, however, was that females reported themselves as harder workers than males. These results are explained as possibly being due to having a sample of females who rated themselves as having unstable intelligence more often than what was reported in previous research. Leondari and Gialamas (2002) went a step further with their research and reported that views of incremental beliefs were not related to actual achievement of either males or females for their participants, students enrolled in elementary through junior high. This finding suggests that the view of intelligence does not actually affect achievement or intelligence directly. This finding, like that of Ablard and Mills, goes against prior research, such as that of Jacobs et al., discussed previously.

Science achievement and science interest are both areas that have been researched thoroughly. From this research it is known that girls are less interested in science than boys (Miller et al., 2006) and generally evidence lower achievement in science than boys (Nosek et al., 2009). Dweck's theory has also been highly researched and supports the theory that girls and boys differ in their views of intelligence in that girls are often more likely to rate intelligence as stable (Jacobs et al., 2002); however, these topics have not been studied in regards to science interest, achievement and implicit theories about science ability specifically in a younger population. This thesis project sets out to address that gap in recent research. Understanding the effects of gender and implicit theory on science interest and achievement is beneficial due to the potential to gain further insight into contributors to the persistent gender gap in science achievement. In light of the research discussed the following hypotheses will be tested:

Hypothesis 1. Older children will exhibit an entity view of science ability compared to younger children.

Hypothesis 2. Females will exhibit an entity view of science ability compared to males.

Hypothesis 3. Females will exhibit less interest in science compared to males.

Hypothesis 4. Females will exhibit lower achievement in science compared to males.

Hypothesis 5. Implicit views of science ability will be significantly and positively correlated with science interest and achievement for both males and females.

Method

Participants

Participants for this study were students who were part of Project GEMS (Gifted Education in Math and Science). Project GEMS is a project funded by the Jacob K. Javits Gifted and Talented Students Education Program that emphasizes science and math achievement and interest in elementary school-aged children. Largely, the students were from minority and/or low-income families. Six elementary schools from one south central Kentucky district were chosen to participate in Project GEMS. These schools were selected based on at least 50% of enrolled students taking part in a free or reduced lunch program. Students enrolled in grade 2 through 6 were eligible to participate in the program (Roberts, 2008). As the program was in its fourth year of implementation, students in the sixth grade could have potentially been part of the program for three years. Fifth grade students could have been part for two years and third grade for one. Third grade candidates for the following year are selected from second graders so those children would not have participated in any of the study measures prior to this research taking place.

The sample consisted of a total of 1,910 students. There were 369 second grade students, 382 third grade students, 354 fourth grade students, 409 fifth grade students, and 396 sixth grade students. Of the total number of students, 986 were female and 924 were male[1]. Demographic information about the participants was collected in conjunction with the student surveys.

---

[1] Demographic data was collected using grade and gender items on a math interest survey unrelated to the current study. The number of participants on each study measure is slightly different due to random attrition.

Measures

Implicit theories of science ability scale. The Implicit Theories of Intelligence Scale for Children (age 10 and older) – Self Form (Dweck, 2000) was used as a basis to create a scale to measure the participants' implicit theories of science. The three questions from this scale were modified to focus on views of science ability rather than intelligence (see Appendix A). This was done by substituting the words "intelligence" with "science ability" in each question. The original scale was found to yield high internal reliability estimates with coefficient alphas ranging from .94 to .98 (Dweck, Chiu, & Hong, 1995). The researchers determined the scale was unrelated to other constructs including self-esteem and confidence in cognitive abilities and was not affected by the political affiliation, religion, or self-presentation concerns of the participants. These results suggested that the scale yielded reliable scores and demonstrated adequate validity. The reliability estimate for the current survey yielded a coefficient alpha of .78.

Science interest survey. A science interest survey was created as part of the Project GEMS identification process and was used in this study (see Appendix B). The survey consisted of 22 items based on Hidi and Renninger's (2006) Four Phase Model of Interest Development and was developed by Wininger (U.S. Department of Education, 2011). The items were answered using a five-point Likert scale. Previous exploratory factor analyses revealed a four factor model: emotion, value, knowledge, and engagement outside of school with coefficient alpha reliability estimates of .89, .74, .84 and .85 for each factor, respectively. Reliability analyses for the present study were calculated with the following coefficient alphas: emotion (items 1-5) .91, value (items 6-8, 20-21) .82, knowledge (items 9-13) .84, and engagement (items 14-19) .88. Item 22 was discarded based on low item correlation and negative impact on the subscale reliability estimate. The item was the only comparison item on the survey evidenced by the wording (“Science is one of the most important subjects in school”). Items 4 and 11 were reverse-scored prior to analyses.

Iowa Test of Basic Skills. Participants completed the Iowa Test of Basic Skills (ITBS; Hoover, Dunbar and Frisbie, 2001), a group administered, standardized, and norm-referenced test that measured achievement. The ITBS Science test consisted of a single, 30-question science section. The ITBS Science test was used to assess each participant’s science achievement. The ITBS was demonstrated to be a psychometrically sound assessment (Lane, 2007). Internal consistency reliability coefficients for the ITBS subtests ranged from the .80s to .90s, and most of the estimates for the totals and composites were in the .90s. Test-retest reliability coefficients were generally in the high .70s and .80s. Construct validity was demonstrated in the process used to create the assessment; the test developers consulted instructional goals for content in schools across the nation and created the assessment based on curriculum content. The correlations between composite and subtest scores were moderate to high.

Procedure

The following procedures have been approved by the Institutional Research Board of Western Kentucky University (see Appendix C). Prior to data collection, parents were given the opportunity to opt out of participation in the study. The student participants whose parents did not opt out were asked to give informed assent. Only when implied consent and student assent were obtained were the students able to participate in the study. The measures of implicit theories of science ability and science interest were posted to an online survey managing system and access was given to each of the six schools. Teachers administered both measures and read the directions and items aloud to the participants. The participants then completed the measures on a school computer. Participants completed the ITBS Science Test via pencil and paper. These forms were sent to the publisher for scoring and results were delivered through secure electronic transmission for analysis. All test procedures were completed in the spring of the current academic year during the same testing window.

Research Design and Analysis

A one-way ANOVA was used to examine potential mean differences in overall composite scores on the implicit theories of science ability measure between grade levels. Additionally, a one-way MANOVA was used to determine the effects that grade may have on implicit views of science ability and science interest measures. For the areas demonstrating significant differences, Tukey HSD was used for pairwise comparisons to determine the specificity of differences. If the first hypothesis is supported, there should be a statistically significant difference in implicit theories of science ability composite scores between grade levels, with older children being more likely to hold entity beliefs and younger children being more likely to hold incremental beliefs of science ability.

A one-way ANOVA was also used to examine potential mean differences in overall composite scores on the implicit theories measure between males and females. If the second hypothesis is supported, there should be a statistically significant difference in implicit theory scores between males and females, with females being more likely to indicate an entity view of science abilities than males. Additionally, to evaluate the third hypothesis a one-way ANOVA was used to determine possible differences in science interest between males and females. If the third hypothesis is supported, overall mean scores of science interest should be significantly higher for males than females.

To evaluate the fourth hypothesis, a one-way ANOVA was used to determine the presence of possible gender differences in science achievement between males and females. If this hypothesis is supported, overall mean scores on the science achievement should be significantly greater for males than females.

Finally, to evaluate the fifth hypothesis, overall composite scores from the implicit theories of science ability measure were correlated with overall composite scores from the science achievement scores and the interest sub-types and overall interest scores. If the fifth hypothesis is supported, there should also be a statistically significant and positive correlation between implicit theories of science ability scores and science achievement scores, where students with scores indicative of incremental beliefs display higher science achievement and students with scores indicative of entity beliefs display lower science achievement scores. Additionally, there should be a statistically significant and positive correlation between implicit theories of science ability and science interest, where students with score indicative of incremental beliefs display higher science interest. Conversely, students with scores indicative of entity beliefs should display lower levels of science interest.

Results

Descriptive statistics were calculated for all variables by grade and are summarized in Table 1. In order to address the first hypothesis, differences in implicit views by grade were examined using a one-way ANOVA. In accordance with hypothesis 1, there were significant differences in implicit scores by grade (see significance levels in Table 2).

Table 1

Descriptive Statistics of Study Measures by Grade

		Implicit Science[a]		Emotion[b]		Value[b]		Knowledge[b]		Engagement[b]		Interest Total[c]	
Grade	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
2	250	2.50	.83	4.08	1.03	4.14	.83	3.69	.96	2.34	1.10	3.51	.71
3	272	2.40	.80	4.26	.90	4.19	.82	3.73	.84	2.43	1.06	3.60	.71
4	279	2.64	.83	4.10	.97	4.33	.77	3.67	.84	2.62	1.06	3.63	.73
5	320	2.75	.83	3.88	1.07	4.09	.95	3.64	.86	2.31	1.12	3.42	.82
6	300	2.65	.75	3.87	.88	4.15	.79	3.67	.73	2.18	.91	3.41	.65
Total	1421	2.60	.82	4.03	.98	4.18	.84	3.68	.84	2.37	1.06	3.51	.73

Note: ITBS Science scores were not included with descriptive statistics due to score scale differences according to grade. Actual scores were converted to z-scores and are reported in Table 3.

[a] Possible scores range from 1-4; Value of overall implicit measure: low scores (< 2) are indicative of an entity view of science ability and high scores (> 2) are indicative of an incremental view of science ability.

[b] Possible score range from 1-5.

[c] Interest Total scores are a composite of all interest sub-measures; possible scores range from 1-5.

One-way ANOVAs were also utilized to determine the possible effect of grade on implicit views of science ability and interest measures and are summarized in Table 2. Grade has a statistically significant effect on implicit science, emotion, value, engagement and interest total scores.

Table 2

Effect of Grade on Study Measures

Measure	*Df*	*F*	*MSE*	*Sig.*	*Partial Eta*^{2}
Implicit Science	4, 1416	8.10	.65	.000**	.02
Emotion	4, 1416	8.08	.95	.000**	.02
Value	4, 1416	3.30	.70	.011*	.01
Knowledge	4, 1416	.41	.71	.798	.00
Engagement	4, 1416	7.02	1.10	.000**	.02
Interest Total	4, 1416	5.39	.53	.000**	.01

*$p < .05$.
**$p < .001$.

Post hoc analyses were used to determine which pair-wise comparisons for grades were significant for implicit views of science ability, significant interest sub-types and overall science interest. Mean differences and standard error estimates are charted in Table 3. When exploring the implicit science measure, second graders evidenced significantly lower scores than fifth graders on the implicit science measure. Third graders evidenced significantly lower scores than the fourth, fifth and sixth graders on the implicit science measure as well. These scores indicated that, on average, the younger students held an entity view of their science abilities in comparison to older peers.

Hypothesis 1 predicted that a significant difference between the younger and older grades would exist; however, the differences were expected to present in the opposite direction.

In regards to the emotion interest sub-type, significant differences were found to exist between third and fifth graders indicating that third graders reported a greater level of liking for science than their older peers. Similarly, third graders evidenced more emotional liking for science than sixth graders. Fourth graders also indicated greater levels of liking for science than fifth graders and sixth graders.

Only one significant difference was found to exist when examining the value interest sub-type. Fourth graders evidenced significantly greater value of science than fifth graders.

When exploring the engagement sub-type of the interest survey, several significant differences between grade levels were found. Second graders reported lower levels of engagement in science than fourth graders. Conversely, third graders reported greater engagement than sixth grade students. Additionally, fourth graders reported greater levels of engagement in comparison to fifth and sixth grade students.

Significant differences were also found when exploring the science interest total scores. Third graders reported greater interest in science overall in comparison to fifth and sixth graders. Fourth graders also reported significantly higher levels of science interest overall in comparison to fifth and sixth graders.

Table 3

Mean Differences and Standard Error Estimates from Tukey HSD Post Hoc Comparisons

Measure	2 v. 3	2 v. 4	2 v. 5	2 v. 6	3 v. 4	3 v. 5	3 v. 6	4 v. 5	4 v. 6	5 v. 6
Implicit Science	.10	.14	.25**	.14	.24**	.34***	.24**	.10	.00	.09
	(.04)	(.07)	(.07)	(.07)	(.07)	(.07)	(.07)	(.07)	(.07)	(.06)
Emotion	.17	.02	.20	.22	.15	.37***	.39***	.22*	.23*	.01
	(.09)	(.08)	(.08)	(.08)	(.08)	(.08)	(.08)	(.08)	(.08)	(.08)
Value	.04	.18	.05	.00	.14	.09	.03	.23*	.17	.06
	(.07)	(.07)	(.07)	(.07)	(.07)	(.07)	(.07)	(.07)	(.07)	(.07)
Engagement	.09	.27*	.03	.16	.18	.12	.25*	.31**	.44***	.13
	(.09)	(.09)	(.09)	(.09)	(.09)	(.09)	(.09)	(.09)	(.09)	(.09)
Interest Total	.08	.12	.08	.10	.04	.17*	.18*	.21**	.22**	.02
	(.06)	(.06)	(.06)	(.06)	(.06)	(.06)	(.06)	(.06)	(.06)	(.06)

* $p < .05$.
** $p < .01$.
*** $p < .001$.

Descriptive statistics were calculated for all variables by gender and are summarized in Table 4. To evaluate the second hypothesis, potential gender differences in implicit theories of science ability were explored using a one-way ANOVA. In opposition to hypothesis 2, females do not indicate scores that are significantly more indicative of an entity view of science ability in comparison to males, F (1, 1649) = .47, p = .49. A one-way ANOVA was used to determine possible gender differences concerning science interest and address the third hypothesis. Females did not indicate significantly lower levels of science interest than males divergent from hypothesis 3, F (1, 1431) = 2.00, p = .16. In order to evaluate the fourth hypothesis, potential gender differences in science achievement were examined using a one-way ANOVA. In accordance with hypothesis 4, females did indicate significantly lower science achievement than males, F (1, 1509) = 10.64, p = .00.

Table 4

Descriptive Statistics of Study Measures by Gender

	Male			Female				
Measure	*N*	*M*	*SD*	*n*	*M*	*SD*	*t*	*Sig.*
ITBS Science[a]	780	0.06	1.05	731	-0.05	.95	-2.04	.042*
Implicit Theories[b]	825	2.59	.82	826	2.58	.81	-.05	.962
Emotion	800	4.00	1.01	805	4.02	.97	.26	.794
Value[c]	777	4.16	.85	766	4.21	.81	1.05	.293
Knowledge	806	3.70	.86	799	3.67	.83	-.84	.400
Engagement	803	2.42	1.08	800	2.35	1.05	-1.21	.225
Interest Total	716	3.52	.76	717	3.50	.71	-.44	.660

[a] Scores are z-scores.
[b] Value of overall implicit measure; low scores (< 2) are indicative of an entity view of science ability and high scores (> 2) are indicative of an incremental view of science ability.
[c] Item number 22 removed.
*2-tailed, $p < .05$, equal variances not assumed.

In part accordance with the fifth hypothesis, the Implicit Theories measure had a significant and positive relationship with science z-scores at each grade level and collapsed across grade level (see Table 4). Conversely, the Implicit Theories measure indicated a positive though non-significant relationship with the total interest measure. The Implicit Theories measure also evidenced a significant and positive relationship with the perceived knowledge sub-measure of the interest inventory for 2nd grade, r (293) = .127, p = .03. A significant and positive relationship was also present between the Implicit Theories measure and the knowledge sub-measure total, r (1592) = .097, p = .00.

Table 5

Correlations Between Implicit Theories Measure and Other Study Measures

Grade	Science Z-score	Emotion	Value	Knowledge	Engagement	Interest Total
2	.11*	.10	.02	.13*	-.07	.04
3	.13*	.10	.07	.09	-.02	.05
4	.36**	.02	-.01	.11	.05	.06
5	.20**	.00	-.00	.09	-.07	.02
6	NA	.03	.08	.09	.01	.05
Total	.20**	.03	.03	.10**	-.03	.03

*p < .05
**p < .01

Discussion

This research study set out to explore the effects that gender and implicit theories of science ability have on science interest and achievement in elementary-aged children. Understanding these effects offers the potential to gain further insight into contributors to the perseverant gender gap in science achievement. Results from this study also have the potential to shed insight into potential contributors to the decreased likelihood of girls pursuing STEM careers. The students in the present study did differ in their implicit views of science ability by grade level. The results found in this study are congruent with prior research which suggests that differences in implicit views should vary by grade (Kurtz-Costes et al., 2005); however, prior research suggests that older students are those who are more likely to express entity views of intelligence and specific abilities. In the present study, the opposite was indicated. Second and third grade students indicated scores suggestive of an entity view of science abilities. A possible explanation for this may lie in the inherent view that children hold of intelligence. Previously discussed research (Kärkkäinen et al., 2008; Kurtz-Costes et al., 2005) suggests that young children view intelligence in terms of the tasks that a person can perform well. In the second and third grades, children have not yet experienced true science instruction or it has simply not been labeled as "science class." Perhaps the decreased implicit rating by these young students is due to lack of awareness with regard to science-based tasks.

Additionally, fourth grade students rated themselves as the grade with the highest levels of science interest. One hypothesized explanation for this finding lies in high-stakes testing; the new Kentucky Performance Rating for Educational Progress (K-PREP) test was implemented during the spring of data collection for the current study. Fourth grade students are the only students tested in the area of science for grades three through six. Second graders are not administered state achievement tests. Perhaps fourth grade students rated themselves as being more interested in science because it was the first year in which science was emphasized as a core class. The novelty of the subject coupled with an emphasis on testing material may have increased student interest in science.

In violation of the second hypothesis, females did not differ significantly from males in their view of implicit theories of science ability. These results were surprising when considering past research results. Female students in the present study did not indicate significantly lower levels of science interest, contrary to the third hypothesis, though females did evidence significantly lower levels of science achievement in comparison to males. The latter finding is in support of the fourth hypothesis. Prior research posits that interest is a mitigating factor in achievement (Häussler & Hoffmann, 2002), though the results of this study suggest that increased interest alone does not directly increase achievement. Rather, as evidenced by results of correlational exploration, the Implicit Theories measure evidenced a significant and positive relationship with achievement at all grade levels in addition to the knowledge sub-scale at grade 4 and the knowledge sub-scale total.

Current study findings suggest that a student’s view of his or her science ability based on Implicit Theories has an effect on that student’s overall science achievement perhaps more so than gender or interest in science alone. This result supports the final hypothesis in part. Conversely, the Implicit Theories measure did not evidence a significant relationship, either positive or negative, with the total interest scale. Based on this result, it can be concluded that for the current study sample, views of implicit abilities are not directly affected by levels of interest. Other research does suggest that implicit theories of ability are closely associated with motivation and achievement in students (Chen, 2012).

Limitations and Future Directions

The current study is hindered by limitations that should be taken into consideration. One drawback is that the students sampled in the current study were also participating in a concurrent longitudinal research study unrelated to the current study. For this reason, two possible limitations arise. First, the students came from a limited geographical area and, thus, current results may not be generalizable to the national population, especially when considering geographical or cultural influences. In addition, these students had also completed multiple self-report measures in short time frame which could have resulted in decreased attention to measure items or the increased desire to answer questions hurriedly so as to be finished with the surveys quickly. This limitation was combatted in part by including reverse-scored items on the interest self-report measure.

Another possible limitation to the current results rests in the practice that teachers were instructed to read survey items to their students. This was to reduce the possibility that limited English proficiency or hindered reading ability would reduce student understanding of survey items. In order to increase efficiency, the surveys were read to groups of students at a time; however, prior research suggests that children, younger more so than older, have impaired listening comprehension due to distractions from background noise (Klatte, Lachmann & Meis, 2010). Future research should address background distractions if study results rely on self-response measures that must be read to participants.

In addition to possible listening comprehension difficulties, self-report measures are also criticized as weak measures due to limited validity. Research cites response styles such as socially desirable responding, acquiescent responding and extreme responding as complications which skew results (Paulhus & Vazire, 2010). Other self-preservation mechanisms, including self-favoring bias, self-enhancement, defensiveness and denial, also affect how respondents answer self-report scales. Future research should explore the validity of self-report measures of interest and implicit views of science ability in addition to collecting corroborating information from outside sources such as teachers or parents.

The current study aims to address the deficit in research concerning the effects of implicit views of science ability on science interest and achievement in elementary-aged children. In addition, this study aims to lend insight into the perseverant gender gap in science interest and achievement. The implications of research findings may help to inform interventions to keep students, especially females, motivated to perform well in science classes and perhaps pursue a STEM career. Previous interventions have been explored. A meta-analysis of the national differences between girls and boys in school determined that a national policy aimed at changing stereotypes of women in science as well as decreasing the sex gap in science engagement would best serve women in terms of achievement in science (Nosek et al., 2009). Others have attempted to segregate classes by sex in order to determine if gender differences are decreased and learning becomes a more positive experience. Research conducted by Friend (2006) deemed this practice ineffective and more detrimental than helpful. The results demonstrated higher incidence of bullying behavior and no significant increases in science achievement for girls.

In her 2006 book, Carol Dweck tailors implicit theories to those who are perhaps not trained in the social sciences and tells how to change one's mindset in order to better cope with difficulty and achieve in the face of adversity. Other research has shown that implicit views, which according to the present study are correlated with achievement, can be taught as well. Intervention data confirms when students are systematically taught to have an incremental view of their abilities, and maintain that view, confidence in abilities does not wane when challenged and those students are more likely to employ problem-solving strategies (Chen, 2012). Future research should address further motivation and implicit theories interventions. Research has shown that incremental views of ability result in continued motivation and increased achievement in children; thus, research into instilling an incremental view of abilities in students is beneficial not only to science achievement but in other specific areas as well.

Addressing limitations in the present study would be beneficial and potentially informative. Perhaps sampling students from varied backgrounds, geographical locations and ages would help to address the limited generalizability of the current study. Additionally, studying implicit views of science ability across time would offer more information as to when, if at all, a shift in implicit view occurs. Understanding when children's view of the malleability of their ability changes may help to identify crucial ages at which to address motivation for science learning. Incorporating more measures by which to measure science interest and implicit views of science ability will aid more credibility to future research as well as result in more useful data for application.

In conclusion, the present study lends valuable information to prior research and demonstrates that implicit views of science ability are correlated with science achievement in elementary-aged children. This finding, in conjunction with prior research findings, emphasizes the importance of considering implicit views of abilities when discussing science achievement and lends insight as a possible way to combat the persistent achievement gap between males and females. Understanding the effects that implicit views of domain specific abilities can have on achievement has the potential to help educators, parents and the students themselves increase motivation and achieve at greater levels.

Appendix A

Implicit Theories of Science Ability Scale

Read each sentence below and then select the one number that shows how much you agree with it. There are no right or wrong answers.

1	2	3	4
Strongly Agree	Agree	Disagree	Strongly Disagree

1. You have a certain amount of science ability, and you really can't do much to change it.
2. Your science ability is something about you that you can't change very much.
3. You can learn new things, but you can't really change your basic science ability.

Appendix B

Science Interest Survey

Please answer the questions below honestly; there are no right or wrong answers.

1	2	3	4	5
Never	Rarely	Sometimes	Most of the time	Always

1. Science is interesting
2. I like science.
3. Science is fun.
4. Science is boring.
5. Science is cool.
6. Learning about science is important.
7. Learning about science is helpful.
8. What I learn in science is useful.
9. I know a lot about science.
10. I am good at science.
11. Science is hard for me.
12. I do well in my science classes.
13. Science is easy for me.
14. I watch television shows about science outside of school.
15. I look at websites about science outside of school.
16. I play science computer games outside of school.
17. I read books about science outside of school.
18. I go places to learn about science outside of school.
19. I like to do science experiments outside of school.

20. Doing well in science is important to me.

21. Science is one of the most important subjects in school.

22. What I learn in science is more useful than what I learn in other classes.

WKU

A LEADING AMERICAN UNIVERSITY WITH INTERNATIONAL REACH
HUMAN SUBJECTS REVIEW BOARD

In future correspondence, please refer to HS10-011, September 3, 2009

Dr. Steve Wininger
Tracy Inman
Center for Gifted Studies
WKU

Dr. Steve Wininger
& Tracy Inman

Your research project, *GEMS 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 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 Full Board Review Level until September 3, 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 # 10-011
APPROVED 9/3/09 to 9/3/10
EXEMPT EXPEDITED FULL BOARD
DATE APPROVED 9/3/09

cc: HS file number Wininger HS10-011

References

Ablard, K. E., & Mills, C. J. (1996). Implicit theories of intelligence and self-perceptions of academically talented adolescents and children. *Journal of Youth and Adolescence*, *25*(2), 137-147.

Astin, H. (1975). Sex differences in mathematical and scientific precocity. *The Journal of Special Education, 9*(1), 79-91.

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across and adolescent transition: A longitudinal study and an intervention. *Child Development*, *78*(1), 246-263.

Chen, J. A. (2012). Implicit theories, epistemic beliefs, and science motivation: A person-centered approach. *Learning and Individual Differences*, *22*,(6), 724-735.

Dweck, C. S., Chiu, C., & Hong, Y. (1995). Implicit theories and their role in judgments and reactions: A word from two perspectives. *Psychological Inquiry*, *6*(4), 267–285.

Dweck, C. S. (2000). *Self-theories: Their role in motivation, personality, and development*. Philadelphia, PA: Psychology Press.

Dweck, C. S. (2006). *Mindset: The new psychology of success*. New York: Random House.

Freedman-Doan, C., Wigfield, A., Eccles, J. S., Blumenfield, P., Arbreton, A., & Harold, R. D. (2000). What am I best at? Grade and gender differences in children's beliefs about ability improvement. *Journal of Applied Developmental Psychology*, *21*(4), 379-402.

Friend, J. (2006). Research on same-gender grouping in eighth grade science classrooms. *Research in Middle Level Education*, *30*(4), 1-15.

Garcia-Cepero, M. C., & McCoach, D. B. (2008). Educators' implicit theories of intelligence and beliefs about the identification of gifted students. *Universitas Psychologica, 8*(2), 295-310.

Häussler, P., & Hoffmann, L. (2002). An intervention study to enhance girls' interest, self concept, and achievement in physics class. *Journal of Research in Science Training, 39*(9), 870-888.

Heyman, G. D., & Dweck, C. S. (1998). Children's thinking about traits: Implications for judgments of the self and others. *Child Development, 64*(2), 391-403.

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

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics.* Washington, DC: AAUW.

Holden, C. (2000). Asia stays on top, U.S. in middle in new global rankings. *Science, 290*(5498).

Hong, Y., Chiu, C., Dweck, C. S., Lin, D. M., & Wan, W. (1999). Implicit theories, attributions, and coping: A meaning system approach. *Journal of Personality and Social Psychology, 77*(3), 588-599.

Hoover, H. D., Dunbar, S. B., & Frisbie, D. A. (2001). *Iowa Tests of Basic Skills Forms A, B and C*. Rolling Meadows, IL: Riverside Publishing Company.

Hyde, J. S., & Linn, M. C. (2006). Gender similarities in mathematics and science. *Science, 314,* 599-600.

Jacobs, J. E., Lanza, S., Osgood, D. W., Eccles, J. S., & Wigfield, A. (2002). Changes in children's self-competence and values: Gender and domain differences across grades one through twelve. *Child Development*, *73*(2), 509-527.

Kärkkäinen, R., Räty, H., & Kasanen, K. (2008). Children's notions of the malleability of their academic competencies. *Social Psychology Education*, *11*, 445-458.

Klatte, M., Lachmann, T., & Meis, M. (2010) Effects of noise and reverberation on speech perception and listening comprehension of children and adults in a classroom-like setting. *Noise Health*, *12*, 270-82.

Kurtz-Costes, B., McCall, R. J., Kinlaw, C. R., Wiesen, C. A., & Joyner, M. H. (2005). What does it mean to be smart? The development of children's beliefs about intelligence in Germany and the United States. *Applied Developmental Psychology*, *26*, 217-233.

Lapointe, A. E., Mead, N. A., & Phillips, G. (1989). A world of differences: An international assessment of mathematics and science. Princeton, NJ: Educational Testing Service.

Lane, S. (2007). Iowa Tests of Basic Skills(r), Forms A and B. In K. Geisinger, R. Spies, J. Carlson, & B. Plake (Eds.), *Mental Measurements Yearbook* (17th ed.). Lincoln, NB: The University of Nebraska Press.

Leonardelli, G. J., Hermann, A. D., Lynch, M. E., & Arkin, R. M. (2003). The shape of self evaluation: Implicit theories of intelligence and judgments of intellectual ability. *Journal of Research in Personality*, *37*, 141-168.

Leondari, A., & Gialamas, V. (2002). Implicit theories, goal orientations, and perceived competence: Impact on students' achievement behavior. *Psychology in the Schools, 39*(3), 279-291.

Marsh, H. W., Trautwein, U., Lüdtke, O., Köller, O., & Baumert, J. (2005). Academic self concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Development, 76*(2), 397-416.

Miller, P. H., Blessing, J. S., & Schwartz, S. (2006). Gender differences in high-school students' views about science. *International Journal of Science Education, 28*(4), 363-381.

Nosek, B. A., Smyth, F. L., Sriram, N., Lindner, N. M., Devos, T., Ayala, A., … Greenwald, A. G. (2009). National differences in gender-science stereotypes predict national sex differences in science and math achievement. *Proceedings of the National Academy of Science, 106*(26), 10593-10597. Retrieved May 17, 2011, from http://www.pnas.org/content/106/26/10593

Paulhus, D. L., & Vazire, S. (2010). The Self-report method. In R.W. Robins, R.C. Fraley, & R.F. Krueger (Eds.), *Handbook of research methods in personality psychology* (224-239). New York: Guilford.

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

U.S. Department of Education. (2011). *Grant performance report (ED 524B): Project status chart* (Report No. S206A080048). Washington, DC: Author.

Winne, P. H., & Nesbit, J. C. (2010). The psychology of academic achievement. *Annual Review of Psychology, 61*, 653-678.

Zuckerman, M., Gagne, M., & Nafshi, I. (2001). Pursuing academic interests: The role of implicit theories. *Journal of Applied Social Psychology, 31*(12), 2621-2631.