Implicit Theory of Intelligence and Gifted Students

A Dissertation

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by

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Abstract

This dissertation is comprised of three independently conducted studies, linked by the theme of investigation into gifted students' implicit theories of intelligence deemed necessary for academic growth in challenging and difficult academic situations. The findings of these studies add to the literature base relating to the measurement of the implicit theory of intelligence of gifted students and to the relationships among the implicit theory of intelligence, academic achievement and further career interest of gifted students. In Study 1, researchers found that the 6-item implicit theories of intelligence scale that Dweck (2000) suggested can be used to assess gifted student populations. Also, Dweck's model of implicit theories of intelligence (Dweck & Leggett, 1988) was specified more clearly with gifted students by demonstrating that there was a positive relationship between an incremental theory of intelligence and learning goals and a negative relationship between an incremental theory of intelligence and performance-avoidance goals, while there was no significant relationship between performance-approach goals and implicit theories of intelligence. In Study 2, researchers strongly corroborated validity evidence of scores from the 6-item implicit theories of intelligence scale by examining measurement invariance of Dweck's 6-item scale between general education students and gifted students. Study 3 was designed to extend the literature on implicit theories of intelligence by investigating whether an incremental theory of intelligence is associated with not only gifted students' academic performance, but also with gifted students' talent-related career interests mediated by other motivational

constructs such as learning goals and intrinsic motivation. This study confirmed that the origin of adaptive achievement behaviors such as accepting challenges is from an incremental view of ability and revealed that intrinsic motivation, which is considered to be a critical factor in gaining high academic achievement and maintaining interest in STEM careers, is also based on an incremental belief of intelligence.

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APPROVAL OF THE DISSERTATION

This dissertation, "Implicit Theory of Intelligence and Gifted Students," has been approved by the Graduate Faculty of the Curry School of Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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DEDICATION

To my mother, Hwa-Soon Yoon (윤화순), who always prays for me, and whom I admire the most in my life

To my father, Moon-Bo Park (박문보), who encouraged me to complete my doctoral program

To my beloved husband, Young-Jun Jeon, whose effort and enthusiasm for his research moved me forward

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Note. This dissertation adheres to the “Three-paper manuscript-style dissertation” outlined in the *Curry School Ph.D. Dissertation Manual* (July, 2015).

Implicit Theory of Intelligence and Gifted Students

Gifted students are those who manifest potential at the upper end of a continuum in any domain of talent even relative to other high-achieving individuals in that domain (Subotnik, Olszewski-Kubillius & Worrell, 2011). The purpose of gifted education is to convert potential into performance for self-actualization of individuals and to maximize the contributions of gifted persons to society at large as they become creative producers who solve problems of contemporary civilization (Renzulli, 2005). However, many gifted students do not reach their potential (Adams et al., 2008). Underachievement and helplessness have been identified as barriers that lead to academic disengagement and hinder gifted students from reaching their potential (Carr, Borkowski, & Maxwell, 1991; Fletcher & Speirs Neumeister, 2012; Roedell, 1984). The large body of literature on implicit theory of intelligence (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2000; Yeager & Dweck, 2012) has provided a potential explanation for why some gifted students successfully achieve while others with the same intellectual abilities show helpless behavior patterns, and subsequently, do not achieve academically.

According to Dweck and Leggett (1988), whether students learn and grow in schools is influenced by an implicit theory of intelligence. Dweck's implicit theory of intelligence is an individual belief about the nature of intelligence consisting of two frameworks: an incremental theory and an entity theory. When students adopt an incremental theory, they believe that their intelligence can be developed through effort; however, students with an entity theory believe that their intelligence is unchangeable and fixed. As a result, students respond differently to academic adversity. According to the theory of implicit intelligence, in a group of students with assessed intellectual abilities that are equal, students with an entity theory shrink from challenges and thus lose opportunities to grow, while students with an incremental theory challenge themselves and thus gain opportunities to successfully achieve and fulfill their potential in challenging and difficult academic situations.

Whitehead (1967), a philosopher, stated that, when people challenge themselves, they can be developed and society can evolve. Based on the current literature about the implicit theory of intelligence, an incremental theory of intelligence would be a critical component to drive gifted students toward challenges, develop their talents, and convert potential into performance. However, little research on the relationship between implicit theory of intelligence and academic performance of gifted students exists. Also, little is known about whether some implicit theory of intelligence scales produce valid and reliable data when used for gifted student populations. Thus, it is important to investigate whether scales to measure implicit theory of intelligence developed for general education student populations yield valid and reliable data when used for gifted student populations and whether gifted students' implicit theories of intelligence are associated with achievements in the domains of their talent.

In this first chapter of the dissertation I briefly describes a mechanism through which an implicit theory of intelligence is associated with academic performance and also describes the effects of the implicit theory of intelligence on academic growth in general education settings. Then, I present three studies investigating the measurement of the implicit theory of intelligence of gifted students and the relationship among the implicit theory of intelligence, academic achievement and career interests of gifted students. Lastly, general implications of the studies are addressed.

The three studies included in the dissertation are:

Park, S., Callahan, C. M., & Ryoo, J. H. (in press). Assessing Gifted Students' Beliefs about Intelligence with a Psychometrically Defensible Scale. *Journal of the Education for the Gifted*, Manuscript accepted for publication.

Park, S., Callahan, C. M., & Ryoo, J. H. (Manuscript ready to submit). Evidence for the Implicit Theories of Intelligence Scale's Measurement Invariance between Non-Identified and Identified Gifted. Manuscript ready to submit for publication.

Park, S. (Manuscript ready to submit). The Influence of Implicit Theory of Math Intelligence, Achievement Goals, Intrinsic Motivation, Mathematics Achievement, and STEM Career Interest on STEM School Students' Success.

Implicit Theory of Intelligence Leading to Challenge and Growth

According to the motivation model of the implicit theory of intelligence (Dweck & Leggett, 1988; Yeager & Dweck, 2012), whether students learn and grow in schools is influenced by which implicit theory of intelligence they hold. The two implicit theories of intelligence, an entity theory and an incremental theory, affect students' achievement behaviors differently. Students holding an incremental theory tend to regard everything that occurs in achievement situations (such as challenges, effort, setbacks) as something to help them learn and grow, while students holding an entity theory tend to consider achievement situations (such as challenges, effort, setbacks) as situations for measuring their ability.

More specifically an implicit theory of intelligence shapes students' achievement goals, as either learning goals or performance goals. In other words, students with an incremental theory pursue learning goals, meaning that they are eager to learn even in academically challenging situations and to exert effort because they believe effort is a key to learning and growth. Although they face academic adversity, they continue to challenge themselves by thinking that they need to work harder or change learning strategies in order to overcome academic difficulty and grow/learn. Consequently, they respond with resilience in the face of academic difficulty and seize the opportunity to grow. On the other hand, students with an entity theory pursue performance goals, which lead students to focus on their performance, such as high grades, instead of learning. Since they think effort reflects their lack of ability, they tend to avoid difficult and challenging tasks so as not to demonstrate their lack of ability in the face of academic difficulty. As a result, students with an entity theory, by avoiding a challenge, might lose their opportunity to learn and grow.

Relationship between implicit theory of intelligence and academic achievement. In empirical research in general education settings, researchers have shown the impact of implicit theory of intelligence on academic performance. Aronson, Fried and Good (2002) examined how the implicit theory of intelligence of African American college students affects academic performance and reported positive effects of an intervention focusing on modification of implicit theory of intelligence on students' grade point averages. Good, Aronson, and Inzlicht (2003) also provided an intervention directed at altering students' implicit theory of intelligence. They examined female students' mathematics performance and minority and low-income students' reading performance. They found that both of the groups in the experimental condition designed to foster an incremental view of intelligence earned higher standardized test scores (either mathematics or reading) than their counterparts in the control condition. In addition, Blackwell et al. (2007), who examined the impact of implicit theories of intelligence on adolescents' mathematics achievement with data over two years of junior high school, found that an intervention guiding students to view intelligence as malleable led to higher scores on the measure of the incremental theory of intelligence and on an assessment of mathematics achievement.

Furthermore, there have been studies about the relationships between beliefs about intelligence and academic achievement in general education settings. For example, Blackwell et al. (2007) demonstrated that students with an incremental theory were more resilient and earned higher grades than students with an entity theory—differences that were associated with differences in achievement goals, beliefs about effort, attributions for setbacks and their learning strategies. Chen and Pajares (2010) examined beliefs about science abilities of sixth graders and found that an incremental view of science ability had direct and indirect effects on adaptive motivational factors such as task goals, self-regulation, self-efficacy and science achievement. They also found that epistemological beliefs mediated the effect of an incremental belief of science ability on achievement goals, self-efficacy, and science achievement. Jones, Wilkins, Long, and Wang (2012) measured ninth graders' beliefs about math ability and confirmed the motivational model of achievement examined by Blackwell et al. using math-specific items and also revealed that interest mediated the relationship between an incremental theory and learning goals.

Current literature about the implicit theory of intelligence indicates that one's implicit theory of intelligence is associated with academic performance in general education settings. However, there is little research that explores the impacts of an implicit theory of intelligence of gifted students on their academic achievement or the relationship between an implicit theory of intelligence and academic achievement in gifted populations. Past research about the implicit theory of intelligence of gifted students focused on the assessment of implicit theory of intelligence of gifted students, the relationship between students' view of intelligence and goals, and differences in implicit theory of intelligence across age and gender (Ablard & Mills, 1996, Ablard, 2002; Dai & Feldhusen, 1996; Feldhusen & Dai, 1997). Since 2000, researchers have compared gifted students' and general education students' implicit theory of intelligence and examined how an intervention focused on teaching an implicit view of intelligence to gifted students affects a change in their implicit theory of intelligence (Hong & Acqui, 2004; Espzrza, Shumow & Schmidt, 2014). However, the findings of these studies were inconsistent, which might stem from different instruments to measure implicit theory of intelligence.

In order to compare findings of studies about the implicit theory of intelligence of gifted students and to corroborate sound evidence about gifted students' theories of intelligence, researchers first need an instrument to yield valid and reliable data. Next, researchers in gifted education should investigate how having a belief in an incremental intelligence may or may not help gifted students continue to achieve in the domain of their talent, and in turn, how such a belief may help them convert their potential into performance.

Three Studies Addressing the Measurement of the Implicit Theory of Intelligence in Gifted Students and Its Relationship to the Achievement Goals, Motivation and Career Interests of Gifted Students

The literature about implicit theory of intelligence suggests that labeling a child as gifted and emphasizing “innate intelligence” by saying that you are “smart” instead of praising “process” by saying that you exert “effort” (Muller & Dweck, 1998) might lead gifted students to adopt an entity theory of intelligence. An entity theory of intelligence might hinder gifted students from converting their potential into performance. Hence, it is important to understand whether gifted students tend to adopt an entity theory of intelligence and whether such a given implicit theory of intelligence is related to the academic performance of gifted students. The three manuscripts reflected in Chapters Two, Three and Four of this three-manuscript dissertation, and briefly summarized below, offer a starting point in the effort to provide such evidence.

Assessing Gifted Students’ Beliefs About Intelligence With a Psychometrically Defensible Scale. The research outcomes in the first study reflect the results of an examination of psychometric properties of Dweck’s implicit theory of intelligence scale and the relationship between implicit theory of intelligence and achievement goal orientations with gifted students who range from 5th grade to 11th grade. Dweck (2000) suggested two types of implicit theory of intelligence scales, an 8-item scale for use with adult populations and a 6-item scale for use with children older than ten years old, and the difference between the two scales is two items which were taken out from the 8-item scale. However, the validity evidence for the structure of both of the scales was based on an 8-item scale and a 3-item scale (Dweck, Chiu, & Hong, 1995), which was the initial version of Dweck's implicit theory of intelligence scale. No further validity evidence has been presented for the use of the 6-item scale for older students or for younger students. Also, although some researchers investigated the implicit theory of intelligence with gifted students, they reported inconsistent findings. Evidence of the validity of scores from Dweck's 6-item scale across age, gender, ability level, and educational background is not available. In addition, despite the fact that performance goals are sometimes related to positive outcomes and sometimes to negative outcomes (e.g., Pintrich, 2000) and that performance goals are separated into performance-approach and performance-avoidance goals, Dweck and her colleagues incorporated the approach-avoidance distinction into performance goals in Dweck's implicit theory of intelligence model.

Therefore, the two overarching research questions posed in the first study were: "What are the psychometric properties of the 8-item and the 6-item scale for measuring the implicit theories of intelligence when used with gifted students?" and "What are the relationships between the implicit theory of intelligence and achievement goals (learning, performance-approach, and performance-avoidance goals) across gender and age? Two hundred thirty-nine students were recruited from participants in a two-week residential summer enrichment program for gifted students (entering grades 5-11). Of 239 students, there were 100 younger students (rising into grades 5-7, 47 females) and 139 older students (rising into grades 8-11, 85 females). The participants completed the 8-item implicit theories of intelligence scale (Dweck, 2000) and the Patterns of Adaptive Learning Survey (PALS; Midgley, Kaplan, Middleton, & Maehr, 1998) to measure learning, performance-approach, and performance-avoidance goals.

Findings of the psychometric properties of the 6-item scale suggest that researchers can use the 6-item scale to measure the implicit theories of intelligence of gifted students. The results of CFA indicated that the 6-item scale is better suited to measure theories of intelligence in gifted students than the 8-item scale. In the 6-item scale, the factor reliability for the entity factor was 0.853 and for the incremental factor it was 0.878. Also, the findings showed that the 6-item scale is measurement invariant across age and gender groups in gifted students. More specifically, when it comes to age group, the results indicated that the 6-item scale is measurement invariant; however, the results of a structural invariance test showed that the factor scores in the younger group are different from those in the older group. That is, students in the older group tend to believe more in an entity theory of intelligence than those in the younger group. In terms of gender group, the 6-item scale is measurement and structurally invariant between males and females.

Further, the relationship between implicit theory of intelligence and goal orientations indicated that when students hold a higher incremental theory of intelligence, they tend to pursue higher learning goals and lower performance-avoidance goals. There was no significant relationship between the performance-approach goal orientation and the implicit theories of intelligence. Also, as students become older, they tend to adopt a lower incremental theory of intelligence and rather tend to pursue higher performance-approach goals and higher performance-avoidance goals. In addition, although age did not have a statistically significant direct impact on learning goal orientation, the implicit theories of intelligence mediated the relationship between age and the learning goal orientation. That is, as students become older, their tendency toward an incremental theory lowers, and thus their tendency toward learning goals also lowers. With regard to differences across gender, student gender was not significantly associated with implicit theories of intelligence or any of the goal orientations.

However, one noted limitation of the study was convenience sampling, which makes generalization of the findings to gifted student populations identified using different criteria difficult. Another limitation was the cross-sectional, rather than longitudinal nature of the study which compared students across age categories rather than following the same students as they matured. Thus, in future studies, researchers should conduct studies about the implicit theory of intelligence using data drawn from samples of gifted students who meet other criteria for giftedness and also conduct a longitudinal study.

Evidence for the Implicit Theories of Intelligence Scale's Measurement Invariance Between Non-Identified and Identified Gifted. The research findings in this second study provide validity evidence for the structure of Dweck's 6-item scale to measure implicit theories of intelligence with both general education students (not identified as gifted) and gifted students. Research on implicit theories of intelligence that compares students in the general population to gifted students is dependent on measuring implicit theories of intelligence accurately in each group. That is, group characteristics such as age, gender, ability level, and educational background may influence validity of scores on a scale (Miller, Linn, & Gronlund, 2011). Thus, a scale should have score validity evidence with the populations being compared. In this study, we examined whether existing measures of implicit theories of intelligence yield reliable and valid data for assessing that construct in both the gifted population and the general population.

Students identified as gifted were recruited from students who had been accepted to attend a two-week residential summer enrichment program for gifted students (grades 5-11). The participants were 100 pre-adolescents (rising into grades 5-7, 47 girls) and 139 adolescents (rising into grades 8-11, 85 girls) who completed the measure used in this study (total N = 239). Students in the summer enrichment program were selected based on the average of two independent ratings of applications, which consisted of two parts: one from students and the other from teachers. Students were asked to submit responses to a two-part writing prompt. Teachers of the students were asked to send ratings of the students on ten items selected from the Scales for Rating the Behavioral Characteristics of Superior Students (SRBCSS; Renzulli, Hartman, & Callahan, 1971) and to provide responses to four open-ended questions eliciting specific examples of student behaviors that are indicative of giftedness. The writing prompts were designed to assess critical and creative thinking abilities on a problem-solving task.

General education students (not selected as gifted) included 75 minority and/or low income students (grades 10-12) who attended the AP Challenge Program (APCP), a structured intervention program providing academic support to AP students from six predominantly low income and high-minority mid-Atlantic high schools. Students were identified for participation in the program by project staff and district counselors and administrators based on four criteria: 1) potential for success in AP courses, but not straight A or B students, 2) not enrolled in AP courses previously, 3) not signed up for AP classes for the following year at the time of selection, and 4) minority and/or low-income background.

For the second study, we first examined the factor structure of the 6-item scale and compared the factor structure of 6-item and 8-item scales when used with general education and gifted students described above. All the fit indices of the 6-item scale (CFI, RMSEA, and SRMR) were either acceptable or good. The results indicated that the construct validity evidence is strong with the two-factor model and suggested that the 6-item scale was the better fit for the data with both general education and gifted students. Next, the reliabilities were calculated using the data from the suggested 6-item scale across both groups yielding reliability estimates of .847 for the incremental theory factor and .849 for the entity theory factor. These two indices of factor reliabilities of the scores from the 6-item scale were within a good range based on the criterion of 0.7 (Nunnally & Bernstein, 1994), meaning the scores from the 6-item scale provide evidence of convergent validity.

Finally, we investigated whether scores on the 6-item scale were invariant between general education students (not selected as gifted) and gifted students so that we could examine (dis-) similarity between the two groups. The results indicated that the 6-item scale did not demonstrate significant differences in configural, loading, and strong invariance tests between gifted and general education student populations. This means that Dweck's 6-item scale captures both incremental theory and entity theory factors across the general education and gifted student groups equally well. Thus, these results support construct validity evidence of scores from the 6-item scale and suggest that researchers can use the briefer 6-item scale with gifted students and the general population of students. Based on the results of the measurement invariance test, structural invariance of the 6-item scale was assessed. The result showed that there was a group mean difference on Dweck's 6-item scale between general education and gifted student populations. The group mean difference (0.323, $p < .05$) on the incremental theory factor was statistically significant, indicating that general education students in the sample tended to accept more of an incremental theory of intelligence than the students in the gifted sample.

One limitation of the current study is unequal sample size. The sample size of the general education students was far smaller than the sample size of the gifted students. Also, the general education student group included 10th through 12th graders while the gifted student group ranged from 5th graders to 11th graders. The different sample size and the different range of age might limit the findings of the study. A second limitation of the study was the convenience sampling method for collecting the data. In future studies, measurement invariance and structural invariance of the 6-item scale should be examined with samples of gifted students identified based on other criteria for giftedness in traditional school settings and with a similar sample size in both of the student groups, including students within a similar range of age.

The Influence of Implicit Theory of Math Intelligence, Achievement Goals, Intrinsic Motivation, Mathematics Achievement, and STEM Career Interest on STEM School Students' Success. Academically gifted, science-focused students in STEM high schools are potential candidates to be future scientists and engineers. However, some gifted students exhibit underachievement in selective school systems such as STEM high schools with selective admission processes and experience loss of interest in STEM areas due to competition from equally talented students (BFLPE; Marsh & Parker, 1984; Marsh & Martin, 2011; Seaton, Marsh, & Craven, 2010). Research about the implicit theory of intelligence provides a potential explanation of why some students successfully achieve and grow while others with same intellectual abilities do not in the face of academic challenge (Blackwellet al., 2007; Dweck, 2000; Yeager & Dweck, 2012). Thus, in this third study, I examined how implicit theory of intelligence affects the learning process and academic achievement of gifted students within the specialized context of STEM schools with selective admission processes, and consequently, their STEM career interests through mediating factors such as achievement goals, intrinsic motivation, and academic achievement in a domain of mathematics.

The sample was 132 students of whom 57 (43.2 %) were male and 75 (56.8%) were female (37.1% ninth graders, 23.5% 10th graders, 22% 11th graders, and 17.4% 12th graders). Students in this sample were attending a specialized STEM high school to which they had been admitted based on the following criteria: Math and verbal scores from the school admission test, ratings on essay responses, Grade Point Averages (GPA) including marks from math, science, English, and social studies taken in 7th grade and the 1st Quarter of 8th grade, a math/science GPA from 7th grade and the first and second quarters of 8th grade, and teacher recommendations. Participants identified as Asian/Asian American (47.7 %), White (40.2 %), African American (8%), Hispanic or Latino (2.3%), or Other (9.1%). Students were recruited by emails to parents of students.

First, I examined if there are the relationships among the implicit theories of math intelligence, math-oriented goal orientations, math-oriented intrinsic motivation, and math achievement. The results showed that students with an incremental theory of math intelligence tended to pursue high math-oriented learning goals which led to high math-oriented intrinsic motivation. The higher the scores of the students on the measure of math-oriented intrinsic motivation, the higher they scored on math achievement. In other words, students with an incremental theory of math intelligence were more likely to earn higher math achievement scores than students with an entity theory of math intelligence mediated by the factors of learning goals and intrinsic motivation. Also, although implicit theories of math intelligence were not significantly related to performance-avoidance goals, performance-avoidance goals indirectly had a negative relationship with math achievement via intrinsic motivation. However, performance-approach goals were not associated with implicit theories of intelligence or intrinsic motivation.

Second, I investigated whether there are the associations among motivational constructs (the implicit theories of math intelligence, math-oriented goal orientations, and math-oriented intrinsic motivation), math achievement and STEM career interest. The results indicated that an incremental theory of math intelligence had a positive relationship with interest in STEM careers, via math-oriented learning goals and math-oriented intrinsic motivation. In other words, students with an incremental theory of math intelligence were more likely to pursue learning goals leading to intrinsic motivation which led students to have high interest in STEM careers than students with an entity theory of math intelligence. However, mathematics achievement was not associated with interest in STEM careers.

Lastly, I examined whether the relationships among motivational constructs (the implicit theories of math intelligence, math-oriented goal orientations, and math-oriented intrinsic motivation), mathematics achievement and interest in STEM careers vary across gender and age from 9th to 12th grade. Age measured by grade was significantly and directly associated with the interest in STEM careers. Interestingly, older students tended to have higher interest in STEM careers than younger students. Other variables except for the interest in STEM careers did not vary across age, and no variables varied across gender. This may mean that specialized STEM school programs for academically gifted students with talents in mathematics and/or science have positive impacts on students' interests in STEM areas. Also, this might indicate that gender is not a critical factor in maintaining interest in STEM careers among academically gifted students with talents in math and/or science who attend specialized STEM schools. These are hypotheses that warrant further study.

There are also some limitations which have to be considered for future studies. The sample size is relatively small for this type of analysis. The use of an online survey method for data collection might have resulted in the small sample size. Also, I have used only self-report measures in the present study. Although researchers reported that questionnaires are more suitable than any other measure for assessing internal psychological characteristics (e.g., Connelly & Ones, 2010; Duckworth, Tsukayama, & May, 2010), some limitations of self-report have been documented, for example, misinterpretation by participant (Duckworth & Yeager, 2015). Thus, it would be worthwhile for researchers to examine the hypothesized model with a large sample size using multiple methods of data collection such as interviews, teacher-report, parents-report questionnaire and/or self- report questionnaire with anchoring vignettes in the future research. Lastly, since this was a cross-sectional study, it would be meaningful to conduct a longitudinal study to examine how gifted students' theories of intelligence, learning goals and intrinsic motivation change within the same population as they grow older.

Implications of the Three Studies

As stated above, the large body of literature on implicit theory of intelligence (Blackwell et al., 2007; Dweck, 2000; Yeager & Dweck, 2012) suggests that the learning process is influenced by one's implicit theory of intelligence. The studies included in this three-manuscript dissertation are designed to examine how the implicit theory of intelligence is manifest in the specific subpopulation of gifted students and to examine factors associated with their learning process. The first study laid the foundation for research on the implicit theory of intelligence of gifted student populations by providing evidence that researchers in the field of gifted education can use Dweck's 6-item implicit theories of intelligence scale for assessing gifted student populations with confidence in the validity of the instrument for that purpose. Also, the first study supported the motivation model of the implicit theory of intelligence with gifted student populations. In addition, the results suggested that it would be important that practitioners continuously guide gifted students to adopt an incremental view of intelligence because some gifted students may accept an entity theory, particularly as they become older, and thus, might pass up opportunities to develop competence in the domain of their talents. The second study added construct-related evidence for scores from Dweck's 6-item implicit theories of intelligence scale by revealing that scores on Dweck's 6-item scale are invariant between general education students (not identified as gifted) and gifted students. The third study extended understanding of influences of the implicit theory of math intelligence on achievement outcomes. More specifically, the study provided evidence of how the implicit theory of intelligence is related to academically gifted students' academic performance and their talent-related career interest through the mediating factors of achievement goals and intrinsic motivation.

The evidence supports use of Dweck's 6-item implicit theories of intelligence scale for assessing both general education and gifted student populations, and documents that gifted students' learning process is also affected by the implicit theory of math intelligence. In addition, it suggests that the implicit theory of math intelligence is associated with gifted students' talent-related career interests as mediated through the motivational constructs of learning goals and intrinsic motivation.

These findings support as the claims of Dweck and her colleagues that educators and practitioners in gifted education settings should lead gifted students to believe that intelligence is malleable and can be developed through effort. Based on the data from this study, an incremental view of intelligence, at least in mathematics leads gifted students to have opportunities to develop their competence in the domain of their talent and to maintain interest in STEM careers. In STEM high schools, teachers should create an educational environment emphasizing an incremental view of intelligence in mathematics and encourage gifted students to continuously challenge themselves in order to develop their talent in mathematics and maintain interest in STEM careers.

However, many would argue that encouraging students to adopt an incremental belief about intelligence and only asking students to challenge themselves are insufficient interventions. Some studies of the effects of the interactions between students' academic motivation and teachers' beliefs about entity or incremental intelligence are critical. Rattan, Good, and Dweck (2012) found that teachers with an incremental theory of intelligence are more likely to judge students to have high ability and use strategies to promote student engagement with the field in which students have difficulty (for example, mathematics) than teachers with an entity theory of intelligence. Students who have an interaction with teachers with an entity theory of intelligence tend to have lowered motivation and lowered expectations for their own performance. Thus, teachers should continuously remind themselves of their mindsets and accept an incremental belief about intelligence.

Also, teachers should make an effort to extend their content knowledge and learn relevant instructional strategies in order to provide gifted students with challenging and differentiated content. According to Siegle, Rubenstein, and Mitchell (2014), students' academic motivation is better fostered by teachers with extensive depth and breadth of content knowledge, and those teachers are more likely to provide challenging and differentiated content because they feel comfortable differentiating content from the familiar textbook and delving deeply into instructional strategies.

Conclusion

The findings of the three studies contribute to the literature on implicit theories of intelligence by investigating the measurement of the implicit theory of intelligence in gifted students and its relationship to the achievement goals, learning motivation and career interests of gifted students. The analyses of data from the first and second study suggest that the Dweck's 6-item implicit theories of intelligence scale can be used to assess implicit theories of intelligence of gifted students. The findings of the third study emphasize on the importance of an incremental theory of intelligence as documented in other studies by showing that an incremental theory of intelligence is related to gifted students' mathematics achievement and their interests in STEM careers mediated by learning goals and intrinsic motivation. In the third study, although the findings showed there is a relationship between an incremental theory of intelligence and gifted students' academic achievement and interest in STEM careers, I examined domain-specific motivational constructs (implicit theories of intelligence, achievement goals, and intrinsic motivation), mathematics-oriented motivational constructs. More research is needed to determine whether these findings generalize to other areas.

Also, the findings from the third study add to the literature on interest in STEM areas. Not so surprisingly, the findings suggest that there was no difference in STEM career interest between females and males among academically gifted students with talent in mathematics and/or science. The participants were recruited from a specialized STEM high school for academically gifted students with talent in mathematics and/or science, and the programs in the STEM high school may have a positive impact on female students' interest in STEM careers. In future studies, it would be worthwhile to interview female students attending a specialized STEM high school with a selective admission process in order to understand more specifically which factors help female students maintain interest in STEM careers.

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MANUSCRIPT ONE

Assessing Gifted Students' Beliefs about Intelligence with a Psychometrically Defensible Scale

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Abstract

The psychometric qualities of the 6- and 8- item implicit theories of intelligence scales that Dweck (2000) suggested were compared using a confirmatory factor analysis with data from 239 gifted students (one hundred 5th-7th grades, 139 8th-11th graders). The results indicate that the 6-item scale fits the data better than the 8-item scale. The factor reliabilities of data from the 6-item scale were 0.853 for the entity theory and 0.878 for the incremental theory. We found evidence for measurement invariance across age and gender using measurement and structural invariance tests. Using the scale to investigate the beliefs about intelligence of gifted students and the association between their beliefs about intelligence and goal orientations, we found that the higher the incremental theory held by gifted students, the higher the learning goals they tend to pursue. Older students had a greater tendency to hold an entity theory than younger students.

Keywords: Implicit theories of intelligence, Goal orientations, Mindset measurement, Gifted students

According to Dweck's motivation model (Dweck & Leggett, 1988), an incremental theory of intelligence is defined as a belief that intelligence is malleable and can be developed through effort. An entity theory of intelligence signifies a belief that intelligence is an unchangeable and fixed entity. In educational settings, Dweck's theory has received considerable attention because of the noted relationship between the views students hold about the malleability of intelligence and their learning orientations and subsequent achievement (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2000; Yeager & Dweck, 2012).

However, some theorists have assumed that the label "gifted" might lead gifted students to accept an entity theory of intelligence (Dweck, 2012; Mueller & Dweck, 1998). Also, Clinkenbeard (2012) stated that as a consequence of focusing on their ability (i.e., because of the assignment of the gifted label) gifted students may develop achievement motivation that is more focused on performance than learning. These assertions led Callahan (2012) to note the importance of further researching the implicit theories of intelligence of gifted students in order to evaluate their validity. To be confident in assessment of the degree to which gifted students hold an entity view of intelligence, researchers must first have measures of implicit theories of intelligence that yield valid and reliable data for assessing the gifted population.

Dweck and her colleagues have offered two different measures of implicit theories of intelligence – a 6-item scale and an 8-item scale (Dweck, 2000). Further, they have recommended the 6-item scale for use with student populations and the 8-item scale for use with adult populations. However, the extant literature does not provide sufficient validity evidence for the structure of the 6-item scale (or the 8-item scale) in younger students in general nor for the gifted population in particular. If one intends to use the measures of the construct in research or one intends to use data from the measures to make decisions about a possible need for intervention, it is crucial to validly and reliably measure a student's implicit theory of intelligence.

Achievement goals are one of the key components in the implicit theory of intelligence model, and Dweck and her colleagues applied learning goals and performance goals to the model (Dweck & Leggett, 1988). However, research on achievement goals suggests that performance goals are separated into performance-approach and performance-avoidance goals (e.g., Elliot & McGregor, 2001), and that performance-approach goals are sometimes related to positive outcomes and sometimes to negative outcomes (e.g., Pintrich, 2000). Thus, it would be necessary to examine more specifically the relationship between gifted students' implicit theories of intelligence and goal orientations by separating performance goals into two types, performance-approach and performance-avoidance.

Hence, the first purpose of this study was to compare the psychometric properties of the 6-item and the 8-item scales developed by Dweck when the scales are used to assess gifted students in order to confirm the most psychometrically defensible scale for use with that population. The second purpose was to explore the relationship between the implicit theories of intelligence and goal orientations (learning, performance-approach, and performance-avoidance goals) among gifted students using the scale with the best evidence of reliability and validity.

Dweck's Implicit Theories of Intelligence

As noted above Dweck's model of motivation (Dweck & Elliott, 1983; Dweck & Leggett, 1988) posits that believing a particular implicit theory orients an individual toward specific goals, and the different types of goals are related to different behavioral responses in the face of challenge (Dweck & Leggett, 1988). People adopting an incremental theory (incremental theorists) believe that their intelligence is malleable and can be developed through effort while those who accept an entity theory (entity theorists) believe their intelligence is fixed. Incremental theorists tend to pursue learning goals which orient them toward challenging tasks, and they exert effort to overcome difficulty whereas entity theorists tend to pursue performance goals leading them to avoid challenges, which limits their growth. In other words, incremental theorists exhibit a mastery-oriented response to difficult tasks; however entity theorists display a helpless response in those situations. Notably, students in these studies showing the helpless response in the face of difficulty were equal in ability to those seeking challenges and showing persistence indicating that behavioral responses, either helpless or mastery-oriented behaviors, do not reflect weak skills or histories of failure (Blackwell et al., 2007; Dweck, 2008). .

Measurement of Dweck's Implicit Theories of Intelligence

Based on the conceptual model of implicit theories of intelligence, Dweck and her colleagues (Dweck, Chiu, & Hong, 1995) developed a scale to measure implicit theories of intelligence. This initial implicit theories of intelligence scale was composed of three items on a 6-point Likert scale ranging from strongly agree to strongly disagree with each item representing a statement of an entity theory of intelligence (Dweck et al. 1995). Dweck and her colleagues reported that the scores on the scale were high on measures of internal consistency (alphas ranged from .94 to .98 on samples ranging from N= 62 to 184 across six validation studies) and test-retest reliability (.80). Factor analysis indicated that the items represented three statistically independent implicit theory scales (intelligence, morality, and world). As evidence of discriminant validity Dweck et al. (1995) also showed that the scale was statistically unrelated to measures of cognitive ability, self-esteem, optimism, or confidence in other people.

Levy, Stroessner, and Dweck (1998), however, raised concerns related to the validity of the implicit theory scales. The first concern was whether disagreement with the three items can be regarded as agreement with the incremental theory even though Chiu, Hong, and Dweck (1997) demonstrated that for people who disagreed with the items of the entity theory, there was a strong tendency to endorse items of the incremental theory. Levy et al. also raised the question of whether agreement with the entity items may represent an acquiescence set, indicating a tendency for informants to agree with statements regardless of content. This concern was raised because the three items included in the scale depict only the entity theory.

In response Levy and Dweck (1997) developed an 8-item scale which included items representing both incremental and entity theories. In 1999, Hong, Chi, Dweck, Lin, and Wan offered validity data for the newly developed 8-item scale based on 96 college students. Their claims for validity rested on the negative correlations between responses to the entity items and to the incremental items (r= -.81 to -.85). Subsequently Dweck (2000) suggested that a 6-item scale (all items taken from the 8-item scale) should be used with students older than ten instead of an 8-item scale. No further validity evidence has been presented for the use of the 6-item scale for older students or for younger students.

A further limitation of the existing research is the lack of data on the generalizability of the scale to specific populations, considered an important aspect of construct validity (Onwuegbuzie et al., 2007). The gifted population has been highlighted in recent educational literature because some educators have assumed that labeling students as gifted might lead to their adoption of entity beliefs (Muller & Dweck, 1998). Further research is necessary to confirm those assertions. To have confidence in the findings of such research we need evidence of the reliability and validity of scores from the scales across age, gender, ability level, and educational background (Miller, Linn, & Gronlund, 2011).

Assessment of the Implicit Theories of Intelligence in Gifted Populations

In past studies, there have been attempts to measure the implicit theories of intelligence of gifted individuals. Ablard and Mills (1996) investigated beliefs about the stability of intelligence using data from third through eleventh grade academically talented students by asking students to describe the stability of intelligence on a 6-point rating scale (from “stays the same” to “changes a lot”). Findings indicated that students’ views of the stability of intelligence were normally distributed, with almost one-half having borderline views. High school students in the sample believed intelligence was more stable than elementary students.

Dai and Feldhusen (1996) studied goal orientations of gifted students and used the measure View of Intelligence adapted from a scale developed by Dweck and Henderson (1988) which includes only entity theory statements. The gifted students (9-17 years old) in their sample tended to hold an incremental theory of intelligence. While no gender difference on beliefs about ability was found, there was a difference across age in beliefs about intelligence. Age group 3 (ages 15-17) tended to accept significantly a higher entity theory than Age group 1 (ages 9-11). Notably, the entity theory statements in their instrument differ from the entity theory items in the implicit theories of intelligence scale developed by Dweck and her colleagues (Dweck, 2000). In a second study, when Feldhusen and Dai (1997) used six items including both entity and incremental theory statements to measure student perception of the malleability of ability (e.g., “Reading, thinking, discussion, increase my ability” and “My abilities are fixed and will not change much”), they found that gifted students tend to accept an incremental view of ability, but no age and gender differences were found. Again, the items that they used are different from the items that Dweck and her colleagues developed (Dweck, 2000). Hsueh (1997) also found that gifted students tend to hold an incremental view of their abilities by measuring it with the three entity statements from Dweck and Henderson (1988).

Hong and Aqui (2004) measured views about ability of high school students with students identified as academically gifted in math, creatively talented in math and not identified as gifted using the five items from the Self-Assessment Questionnaire (SAQ, Hong, 2001), they found students’ beliefs about ability (intelligence) were similar across gender and across the two types of giftedness and the not identified sample. Students in this study were neither particularly entity theorists nor incremental theorists. Recently other researchers (Siegle et al, 2010; Snyder, Barger, Wormington, Schwartz-Bloom, & Linnenbrink-Garcia, 2013) have used Dweck’s (2000) 8-item scale to measure the implicit theories of intelligence among high-ability college students. Siegle et al. (2010)

revealed that male students attributed their success to ability whereas female students attributed their success to effort. They suggested that attributing success to ability implies adopting an entity theory of intelligence while attributing success to effort implies endorsing an incremental theory of intelligence. In addition, Snyder et al. (2013) found that timing of identification was not associated with implicit beliefs, but level of academic ability was a significant predictor of implicit beliefs. Higher ability students who had been previously identified as gifted at any point in time tended to endorse implicit entity beliefs more than relatively lower ability students who had also been identified.

In past studies regarding the implicit theories of intelligence of gifted students the scales used for gifted students varied considerably --perhaps contributing to the heterogeneity of findings. Also, age differences in the implicit theories of intelligence were found in some studies (Ablard & Mills, 1996; Dai & Feldhusen, 1996), but not others (Feldhusen and Dai (1997). In addition, most of the studies with elementary through high school students (Ablard & Mills, 1996; Dai & Feldhusen, 1996; Feldhusen & Dai, 1997; Hong & Acqui, 2004) did not find gender differences in implicit theories of intelligence, whereas Siegle et al. (2010) reported gender differences with college students.

Implicit Theories of Intelligence and Goal Orientations

In Dweck’s model of motivation (Dweck & Leggett, 1988; Blackwell et al., 2007), goal orientations play important roles as mediators linking implicit theories of intelligence to academic achievement. Research on goal orientations indicates that there is a significant correlation between students’ goal orientations and their academic performance (e.g., Barron & Harackiewicz, 2001; Dweck & Leggett, 1988; Elliot & Church, 1997; Grant & Dweck, 2003). Some researchers categorize goal orientations in three ways (dichotomous, trichotomous, and 2x2) (e.g., Elliot & McGregor, 2001), but Dweck and her colleagues have applied a dichotomous approach applying learning goal and performance goal orientations to the model of motivation. Students pursuing a learning goal orientation tend to seek to increase competency, focus on mastery-oriented learning, and accept challenging tasks (Dweck, 1986; Elliot & Dweck, 1988). On the other hand, students pursuing a performance goal orientation tend to complete tasks to seek favorable social recognition, show less cognitive engagement, and avoid challenging tasks in order to avoid any demonstration of lack of ability (Elliot & Dweck, 1988; Meece, Blumenfeld, & Hoyle, 1988).

However, according to researchers who apply a trichotomous approach, a performance goal orientation sometimes is related to positive outcomes and sometimes to negative outcomes (e.g., Pintrich, 2000). Those researchers conceptualize performance goals in terms of either performance-approach or performance-avoidance goals (e.g., Elliot & McGregor, 2001). Performance-approach goals describe the objective of demonstrating ability in order to receive positive judgmental feedback; performance-avoidance goals indicate one's aim of avoiding the demonstration of lack of ability (Midgley, Kaplan, Middleton, & Maehr, 1998). Although some researchers stated the positive effects of performance-approach goals on students' academic performance, according to Midgley, Kaplan, and Middleton (2001), students pursuing performance-approach goals would be vulnerable to an attack of learned helplessness and could shift to performance-avoidance goals when they face failure.

The Current Study

The 6-item scale for measuring implicit theories of intelligence for students differs in two items from the 8-item scale with the 6-item scale a subset of the 8-item scale. The two scales were examined to determine their comparative psychometric suitability for measuring implicit theories of intelligence. Further, to provide evidence of generalizability to a specific subpopulation, we compared the psychometric properties of the 6-item and 8-item implicit theories of intelligence scales with gifted students. Specifically, we investigated two sets of research questions. First, what are the psychometric properties of the recommended 6-item scale for measuring the implicit theories of intelligence when used with gifted students? (1) Does the 6-item scale fit the data from gifted students better than the 8-item scale? (2) What is the estimated reliability of scores on the scale that emerges as the "best fit" in confirmatory factor analysis of scores of gifted students? (3) Do scores on the scales exhibit measurement invariance across gender and age?

The second set of research questions reflects examination of the relationship between views of implicit theories of intelligence and goal orientations in gifted students. (1) Among gifted students, are beliefs about intelligence related to goal orientations? Is a more incremental theory of intelligence associated with a tendency toward a learning goal orientation? (2) Among gifted students, is there a difference in the theories of intelligence and goal orientations across age? Do males and females differ in their theories of intelligence and goal orientations?

Method

Participants

Subjects were recruited from participants in a two-week residential summer enrichment program for gifted students (entering grades 5-11[1]) in the state of Virginia. The initial screening for participation comes from the solicitation of applications for this program to students already identified as gifted and participating in gifted and talented programs in their home schools. Students were then further screened with acceptance to the program based on the average of two ratings of applications by two independent raters. The application is comprised of 1) student responses to a two-part writing prompt designed to assess critical and creative thinking abilities on a problem-solving task (students are charged with gathering data and then responding to the issue) and 2) teacher ratings of the students on ten items selected from Scales for Rating the Behavioral Characteristics of Superior Students (SRBCSS; Renzulli, Hartman, & Callahan, 1971), and 3) teacher responses to four open-ended questions eliciting specific examples of student behaviors that are indicative of giftedness. The problem solving task is rated on a rubric comprised of four factors describing creative products derived from Besemer (1998). Approximately two-thirds of applicants are accepted to the program.

The 239 participants in the study were recruited using email solicitations and by meeting with parents at registration. Consent forms were collected from parents of the participants. One hundred younger students (rising into grades 5-7, 47 females), and 139 older students (rising into grades 8-11, 85 females) participated in the study. Slightly less than fifty-eight percent of the students self-identified as Caucasian American. African Americans comprised 7.0 % of the sample; Asian Americans made up 20.6 % of the sample; Latino or Hispanic was the ethnicity reported by 2.2 %; and the remaining

[1] Students have just completed grades 4-10.

students chose “other” or did not self-identify (12.7 %). The participants were from the total 864 students accepted to the program. All but 57 students in the program paid full tuition; the remaining students received partial scholarships based on need.

Instruments

Theories of Intelligence. Implicit theories of intelligence were measured by the Implicit Theories of Intelligence Scale (Dweck, 2000). The 6-item scale recommended for adolescents is a subset of the items on the 8-item scale which consists of four entity theory statements (e.g., You have a certain amount of intelligence, and you can’t really do much to change it) and four incremental theory statements (e.g., No matter who you are, you can significantly change your intelligence level). To examine the validity of use of the 6-item rather than the 8-item scale per Dweck’s suggestion that the 6-item scale was more acceptable for adolescents, the 8-item scale was administered and the psychometric properties of the full 8-item scale were compared to those of the embedded 6-item scale. In this study, in order to apply structural equation modeling to the hypothesized model in Figure 1, we reverse-scored items in the incremental theory factor, so that a high score (6) of the implicit theories of intelligence scale means a strong agreement with an incremental theory and a low score (1) represents an entity theory as in Blackwell et al. (2007).

Learning, performance-approach, and performance-avoidance goals. Items relating to a learning goal orientation, a performance-approach goal orientation, and a performance-avoidance goal orientation were selected from the Patterns of Adaptive Leaning Survey (PALS; Midgley et al., 1998). Midgley et al. (1998) provided evidence of internal consistency (between .73 and .81 for task goals, between .62 and .84 for ability-approach goals, and .84 for ability-avoid goals) as well as convergent and divergent validity of this scale with samples of elementary and middle school students. All items were scored with the high end (6) representing high learning-goals (e.g., I like schoolwork that I'll learn from, even if I make a lot of mistakes), high performance-approach goals (e.g., I would feel really good if I were the only one who could answer the teachers' questions in class), and high performance-avoidance goals (e.g., It's very important to me that I don't look stupid in my classes). We calculated the scale reliability estimate developed by Raykov (2001, 2004) for the factor reliability estimate reconciling issues with Cronbach's coefficients within CFA (Brown, 2006). The factor reliabilities of the three goal subscales with the current sample was 0.891 for the learning goal orientation (a task goal orientation), 0.845 for the performance-approach goal orientation (an ability-approach goal orientation), and 0.859 for the performance-avoidance goal orientation (an ability-avoid goal orientation).

Data Analysis

For the first set of research questions, we ran two CFAs: one with the 6-item scale and the other with the 8-item scale and also tested measurement and structural invariances. In order to determine the scale with the best fit using the CFAs, we compared approximate fit indices including root mean square error of approximation (RMSEA), comparative fit index (CFI), and standardized root mean square residual (SRMR). The criteria for acceptable model fit are less than .08 for both RMSEA and SRMR, and greater than .90 for CFI (Bentler, 1990; Browne & Cudeck, 1993; Hu & Bentler, 1999). To investigate whether the instrument performs similarly across age (younger group: 5th-7th grade students, older group: 8th-11th) and gender groups, measurement invariance was tested based on the following four steps (step 1: Configural Invariance, step 2: Weak (Metric) Invariance, step 3: Strong (Intercept) Invariance, step 4: Strict Factorial Invariance), and structural invariance was tested using three steps (step 5: Test the equality of factor variances over the weak (metric) invariance, step 6: Test the equality of factor covariance over the weak (metric) invariance, step 7: Test the latent mean difference over the intercept invariance) (Brown, 2006). To confirm the level of invariance described below, we applied the criterion suggested by Cheung and Rensvold (2002) to retain invariance when the difference of CFI is less than 0.01.

The reliabilities of factors were examined using the factor rho coefficient (Raykov, 1997, 2004), which is a ratio of explained variance to total variance from CFA parameters. In CFA, factor loadings, error variances and error covariances are estimated, which influence true and total variance. Thus, to measure scale reliability within CFA model, factor reliability facilitating the CFA estimates is more proper than Cronbach's alpha computed by using unrefined composite score for the scale (Brown, 2006).

For the second set of research questions, we calculated descriptive statistics on the implicit theories of intelligence and the goal orientations of the sample, calculated correlations between variables, and applied structural equation modeling to the hypothesized model in Figure 1. We used grades (5-11) instead of grouping grades (younger vs. older) to investigate the effect of age on the implicit theories of intelligence and goal orientations and found the relationship between age (grades) and outcome variables to be linear. Due to the high correlation, -0.824, between the entity factor and the incremental factor, we applied a 2^{nd} order measurement model for the incremental theory consistent with the measurement model for incremental theory used in Blackwell et al. (2007). The hypothesized model was modified by considering the residual correlations in the measurement model for the goal orientations. Out of 17 items for goal orientations, seven items have only one missing data point, and one item has two missing data points. There were no other missing data points. Because missing data are missing at random (Rubin, 1976), the missing data were handled by applying full information maximum likelihood estimate (Enders & Bandalos, 2001) in analyses. All of analyses were done using Mplus software (1998-2012).

[Figure 1]

Results

Psychometric Properties of the Implicit Theories of Intelligence Scale

Confirmatory Factor Analysis. Confirmatory factor analysis of the data from the 6-item and 8-item scales were used to judge whether the 6-item scale fits the data from gifted students better than the 8-item scale. In order to compare the two scales, we examined fit indices for the two scales. All of the fit indices of the 6-item scale (χ^2_8 = 12.767 (p = .120), CFI=.994, RMSEA=.051, and SRMR=.021) are in the good range (according to the criteria of Hu & Bentler (1999)), and the CFI (.965) and SRMR (.037) for the 8-item scale are also in the good range. However, the RMSEA (.102) for the 8-item scale is in the “not acceptable” range (χ^2_{19} = 64.288 (p < .001)). In the 6-item scale, the factor correlation between the incremental factor and the entity factor was -.824 (SE=.032, p<.001). This high negative correlation indicates that as the incremental factor increases, the entity factor decreases. Based on the results of CFA, we concluded that the 6-item scale is better suited to measure theories of intelligence in gifted students than the

8-item scale. Hence we used the 6-item scale for further analyses. Results are summarized in Table 1.

[Table 1]

Reliabilities of the factors. In the 6-item scale, the factor reliability for the entity factor is 0.853; for the incremental factor it is 0.878. In the 8-item scale, the factor reliability for the entity factor is .885 and for the incremental factor it is .898.

Multigroup Analysis. To determine whether measurement and structural invariances hold between age groups on the proposed 6-item scale, participants were divided into two age groups based on grade: younger students (students entering grades 5-7) and older students (students entering grades 8-11). The younger group was established based on typical age range in those grades being 10-12 (pre-adolescent) and the typical age range of rising 8^{th} through 11^{th} graders being 13-16 (adolescent). As noted earlier, model invariance is tested by first fitting the model to each group and then constraining model parameters to equality between groups. At each step of the process an additional set of parameters is constrained to equality in addition to the constraint(s) in the previous model. This results in a series of nested models that can be evaluated by the differences in CFIs. Cheung and Rensvold (2002) recommend the criterion of a difference in CFI of less than .01 as an indicator of invariance.

By specifying the 6-item scale as a two-factor model fixing the first items' loadings as 1 and factor means as 0 for identification in each group, we estimated the configural model. As shown in the Table 2, the configural model indicates a good fit (RMSEA=0.059, CFI=0.993 and SRMR=0.026). Thus, we tested the weak invariance model, the second step of measurement invariance tests. In the weak invariance model, we fixed the factor variances in the younger group as 1 but freely estimated them in the older group so that the estimates of factor loadings are not distorted by the fixed variance in the older group. The factor means were fixed to 0 in both groups. All loadings were constrained to be equal across groups, but all intercepts and error variances were still freely estimated. The weak invariance model fit well and did not differ from the configural model (Δ *CFI* = - 0.001 < 0.01), which allows us to test the strong invariance model. In the strong invariance test, we fixed factor variances and means as 1 and 0, respectively, in the younger group but freely estimated those in the older group because we wished to compare the intercept differences that are not affected by the difference of factor means. Now, all factor loadings and item intercepts were constrained to be equal across groups but all error variances were freely estimated to differ across groups. The strong invariance model fit well and did not differ from the weak model (Δ *CFI* = 0.003 < 0.01). Furthermore, the strict invariance model was examined by fixing the factor variance and mean as 1 and 0, respectively, in the younger group but estimating those in the older group. In addition, all residual variances were constrained to be equal across groups. The strict invariance model did not fit well in terms of RMSEA=0.1 and SRMR=0.085, and the model degraded fit from the strong invariance model (Δ *CFI* = 0.031 > 0.01). Although the strict invariance model did not fit well, we can consider the 6-item scale is measurement invariant because strong invariance was achieved.

Based on the full measurement invariance, structural invariance was then tested with three additional models: the factor equal variance model, the factor equal covariance model, and the factor mean model. The first two models were sequentially tested from the weak invariance model because the comparison of factor variances and covariances are valid when the measurement holds up to weak invariance. On the other hand, the factor mean model constructed from the strong invariance was compared with the factor covariance model because the comparison of factor means across groups is valid under the strong measurement invariance (Brown, 2006). The factor variance in the older group was constrained to 1, resulting in no difference from the weak invariance ($\Delta CFI = 0.005 < 0.01$). The factor covariance model constraining the covariance between the entity and incremental factors in the older group did not differ from the factor covariance model in the younger group when constraining the covariance between the entity and incremental factors in that group ($\Delta CFI = 0.002 < 0.01$). Thus, we conclude that the factor variances and covariances are equal across younger and older groups. However, the factor mean model constraining the factor means as 0 in the older group degrades fit from the factor covariance model ($\Delta CFI = 0.017 > 0.01$), which indicates that the factor scores in the younger group are different from those in the older group. That is, when we fixed the entity and incremental means as 0 in the younger group, the entity and incremental means in the older group were -0.369 and 0.544, respectively. In other words, older students tend to adopt more of an entity theory than younger students, and younger students tend to pursue more of an incremental theory compared to older students. These mean differences across the age group are substantial.

In the full gender group, the full measurement invariance (the strong invariance) was achieved. Furthermore, the factor mean model did not differ from the factor covariance model, indicating that the factor mean of the male group does not differ from the factor mean of the female group. That is, both the male and female groups showed both measurement and structural invariance. The results are summarized in Table 2.

[Table 2]

Implicit Theories of Intelligence and Goal Orientations of Gifted Students

Association between Implicit Theory of Intelligence and Goal Orientation. The hypothesized model (Figure 1) was modified with residual correlations on the measurement models of goal orientation. Based on the modification indices, five residual correlations were added to improve the overall model fitting: items 5 and 6 (actual item numbers: items 15 & 21) in the learning goal orientation[2], items 2 and 3 (actual item numbers, items 6 & 10) and items 4 and 5 (items 12 & 18) in the performance-approach goal orientation[3], items 1 and 6 (items 3 & 20) and items 2 and 3 (items 7 & 9) in the performance-avoidance goal orientation[4].

The modification indices reflect the association among items. The correlated residuals likely resulted from the similar wording or content overlap of items designed to measure each latent construct. For example, items 5 and 6 on the learning goal orientation factor include similar content reflecting “interested and enjoy” implying a level of engagement; no other items on that factor contain wording related to engagement. In terms of the performance-approach goal orientation factor, items 2, 3, 4, and 5 contain “smarter or better” implying a sense of comparison to others while the other (item 1) did not. Also, it seems that items 2 and 3 include a reference such as “teachers or schools” as a frame to show how smart I am while items 4 and 5 do not. When it comes to the

[2] Item 15=I do my school work because I’m interested in it. Item 21=An important reason I do my school work is because I enjoy it.
[3] Item 6=I’d like to show my teachers that I’m smarter than the other students in my classes. Item 10=I would feel successful in school if I did better than most of the other students. Item 12=Doing better than other students in school is important to me. Item 18=I want to do better than other students in my classes.
[4] Item 3=It’s very important to me that I don’t look stupid in my classes. Item 20= The reason I do my school work is so my teachers don’t think I know less than others. Item 7= The reason I do my work is so others won’t think I’m dumb. Item 9=An important reason I do my school work is so that I don’t embarrass myself.

performance-avoidance goal orientation factor, items 1 and 6 include a reference such as "teachers or classes" as a frame to reflect "foolish" while items 2 and 3 do not have any such conceptual reference. To account for the high correlation between incremental theory and entity theory factors, we considered a second-order factor model that included the second order factor as the Implicit Theories of Intelligence (ITI). The high correlation ($r = .824$) between the two constructs did not support the discriminant validity on the 6-item scale because the factor correlation is slightly higher than the benchmark, i.e., above .8 or .85 as suggested by Brown (2006). In this situation, it is a common research strategy to re-specify the model by collapsing the dimensions into a single factor. However, the single factor model (1 unidimensional model) provides an unacceptable fit index (RMSEA=.183), although CFI=.920 and SRMR=.046 were acceptable. As another re-specification, Brown (2006) suggests a 2^{nd} order factor model to account for the high correlation. The 2^{nd} order factor model was tested because it is appealing and consistent with the literature of the implicit theories of intelligence; that is, the existence of the incremental theory and the entity theory. The three goal orientations (learning goal, performance-approach goal, and performance-avoidance goal orientations) were treated as latent variables (Midgley et al., 1998). The model fit well ($\chi^2_{218} = 297.721$ ($p = .003$), RMSEA=.040 with 90% confidence interval of [.028, .051], CFI=.972, SRMR=.054). The model is shown in Figure 2.

As shown in Tables 3 and 4, the Implicit Theories of Intelligence factor (ITI, 2^{nd} order factor of the entity and incremental factors in the measurement models) positively predicts the learning goal orientation (unstandardized regression coefficient=.273 ($p < .001$), d = .377) but negatively predicts the performance-avoidance goal orientation (unstandardized regression coefficient=-.160 ($p = .047$), d = -0.154). This means that a 1-unit increase on the incremental theory of intelligence predicts a 0.273-point increase on the learning goal orientation and a 0.160-point decrease on the performance avoidance goal. Following Cohen's guidelines (d = .20, .50, and .80 for small, medium, and large effect, respectively) in Brown (2015), the effect size of the ITI difference for the learning goal orientation is between small and medium while the effect size of the ITI difference for the performance-avoidance goal orientation is small. On the other hand, the performance-approach goal orientation was not significantly predicted by the Implicit Theories of Intelligence factor (unstandardized regression coefficient=-.023 ($p = .726$). The model of the association between the implicit theories of intelligence and goal orientations is shown in Figure 2.

[Tables 3 and 4]

[Figure 2]

Differences by Age (Grade) and Gender. To examine the effect of the covariates of age and gender, we fit the model with covariates in Figure 3. The model fit well ($\chi^2_{256} = 368.804$ ($p < .001$), RMSEA=.044 with 90% confidence interval of [.034, .054], CFI=.961, SRMR=.054). Age (measured by grade) negatively predicts the Implicit Theories of Intelligence factor (unstandardized regression coefficient=-.149 ($p < .001$), d = -.255) but positively predicts the performance-approach goal orientation (unstandardized regression coefficient=.152 ($p < .001$), d = .302) and the performance-avoidance goal orientation (unstandardized regression coefficient=.131 ($p = .003$), d = .217). That is, a one-grade increase on the grade variable predicts a 0.149-point decrease on the incremental theory of intelligence, controlling for gender while a one-grade increase on the grade variable predicts a 0.152-point increase on the performance-approach goal orientation and a 0.131- point increase on the performance-avoidance goal orientation, controlling for the Implicit Theories of Intelligence and gender variables. These effect sizes of the age differences for the ITI, the performance-approach goal orientation and the performance-avoidance goal orientation are between small and medium. The total effect of the age on the performance-approach goal orientation is .146 meaning that for every one-grade increase in grade, we expect about a .146 -point increase on the performance-approach goal orientation. Similarly, the total effect of the age on the performance-avoidance goal orientation is .145 meaning that for every one-grade increase, we expect about a .145-point increase on the performance-avoidance goal orientation. Also, although age did not have a statistically significant direct impact on learning goal orientations, the Implicit Theories of Intelligence factor mediated the relationship between age and learning goal orientation. This indicates that as students become older, their tendency toward an incremental theory lowers, and thus their tendency toward learning goals is also lower. On the other hand, student gender was not significantly associated with the Implicit Theories of Intelligence factor or any of the goal orientations. The results were summarized in Tables 5 and 6.

[Figure 3]

[Tables 5 and 6]

Discussion

Dweck's 6-item scale is a better fit for the data from our sample of gifted students than the 8-item scale, and the factor reliability estimates of scores from both entity and incremental factors of the 6-item scale were sufficiently high to warrant use of the scale for research purposes—even higher than the internal reliability and the test-retest reliability estimates that Blackwell et al. (2007) reported in their assessment of students from the general education population. Further, the results suggest that the 6-item scale is measurement invariant across age and gender groups in this sample of gifted students. The 6-item scale did not show a statistically significant difference on tests of equal factor loadings, equal indicator intercept, or equal factor variances across both age and gender groups. All things considered, the psychometric properties of the 6-item scale indicate that researchers can use the 6-item scale to measure the implicit theories of intelligence of gifted students.

Also, the results from the current study suggest that gifted students who adopt a stronger incremental theory of intelligence tend to pursue a learning goal orientation. In other words, gifted students (grade 5 through 11) who believed their intelligence is malleable and changeable tended to consider achievement situations as opportunities to improve their competence, and thus, set up goals to acquire new knowledge or skills and seek challenges. This finding also indicates that gifted students with a higher incremental theory of intelligence tend to believe working hard and making effort are necessary to extend their mastery. This result supports the motivation model of the implicit theories of intelligence (Dweck & Leggett, 1988; Dweck, 2000) and is consistent with the empirical findings from studies with general education populations (Blackwell et al., 2007; Chen & Pajares, 2010; Dweck, 2000; Jones, Wilkins, Long, & Wang 2012) and studies with gifted populations (Dai & Feldhusen, 1996; Feldhusen & Dai, 1997; Hsueh, 1997).

When it comes to performance-approach and performance-avoidance goals, our data suggest that as gifted students adopt a higher incremental theory of intelligence, they pursue lower performance-avoidance goals. Gifted students who think that their intelligence can be developed through effort tend *not* to set goals which reflect avoiding tasks that might result in the demonstration of their lack of ability. Conversely, gifted students who believe that their intelligence is fixed tend to select goals to avoid negative judgments of competence. They are more likely to regard achievement situations as measures of their competence. This finding suggests that gifted students with an entity theory also might exhibit a helpless behavioral pattern -- avoiding challenging tasks so they will not to be judged incompetent much as other data has suggested in the case with students in the general education population[5] (Blackwell et al., 2007; Chen & Pajares, 2010; Dweck, 2000; Jones et al., 2012). Because the negative association between an incremental theory of intelligence and performance-approach goals was not statistically significant with gifted students, we can only affirm one aspect of the hypothesized relationship between the two distinct types of performance goals. This finding supports the Chen and Pajares's (2010) study with general education students. In their study, an entity theory of intelligence was positively related to a performance-avoidance goal, and a performance-avoidance goal was indirectly negatively associated with students' final grades.

In order to further understand whether gifted students' implicit theories of intelligence are associated with academic achievement through mediating factors such as goal orientations, studies of the mechanisms through which an incremental theory of intelligence is related to gifted students' academic achievement are needed. While the

[5] Note that we use the term general education population rather than students not identified as gifted because the samples in other studies may have included gifted students.

data do not extend to the influence on achievement outcomes, these findings suggest that exhortations to influence gifted students to adopt a malleable, incremental view of intelligence may, indeed, be warranted.

In addition, in the structural equation modeling some residuals of indicators in goal orientation factors were correlated based on the modification indices and similar wordings or content overlap of items used to measure each of the latent constructs, and the modified model fitting led to the improvement of the overall model fit. In Chen and Pajares's (2010) study, they calculated and used a composite score for each goal orientation in the path model to examine relationships between epistemological beliefs, beliefs about intelligence, three goal orientations, self-efficacy, self-regulation, and final grades. Thus, in future studies, researchers should further examine the psychometric properties of the goal orientation instrument.

Furthermore, we found substantial factor mean scores differences between the pre-adolescent and adolescent age groups with adolescents tending to believe more in an entity theory of intelligence than pre-adolescents, and pre-adolescents tending to adopt more of an incremental theory than adolescents. The results of the SEM also suggest that older gifted students have a greater tendency to hold an entity theory and pursue higher performance-approach and performance-avoidance goals. That is, older gifted students are more likely to hold the belief that their intelligence is fixed and are more likely to set goals which lead to a high likelihood of receiving positive judgment and to avoid being judged as incompetent. Unfortunately, this may lead them to avoid challenging tasks.

Gender was not significantly associated with an incremental theory of intelligence nor was it related to any of the goal orientations. This result is consonant with the findings from Hong and Aqui (2004) that gender differences were not found on students' beliefs about either general intellectual ability or math ability. However, this is not consistent with findings from Siegle et al. (2010) who found that male students tend to hold higher entity beliefs about ability while female students tend to hold higher incremental beliefs about ability. These findings also differ from those of Chen and Pajares (2010) who reported that boys held slightly higher incremental views of ability than did girls. The inconsistent results may stem from the differing samples and/or the domains on which researchers focused. Further study is necessary to examine differences across gender and diverse ages and domains and the potential interactions across these variables.

Limitations

The first limitation of the study is the convenience sample of gifted students. While the students in the program are selected from a large applicant pool based on characteristics of gifted students and following recommendations in the literature that multiple indicators of giftedness be used to identify gifted students, the lack of aptitude tests scores makes generalizability to students identified using test scores as the primary criteria for defining giftedness difficult. Hence, in future studies, researchers should conduct the measurement invariance tests using samples drawn from samples of gifted students who meet other criteria for giftedness. The group from which this population was sampled was tuition-paying students attending a summer program for gifted students. While some attendees are on partial scholarship, we did not collect SES data on our sample so we could not test for differences by that variable nor can we generalize to populations not similar in terms of this demographic.

Second, we did not assess the students on two separate versions of the instrument –the 6-item scale and the 8-items scale. We felt that given that the 8-item scale includes the 6-item scale, the students may have found taking two apparently very similar assessments to be redundant and confusing. However, it is possible that the inclusion of the 2 additional items could have influenced responses on the 6 embedded items. Third, the data provide only cross sectional findings which suggest differences between pre-adolescents and adolescents; a longitudinal study would allow for examination of how and when the theories of intelligence change in the population.

Lastly, in the structural equation modeling used to examine the relationship between the implicit theories of intelligence and goal orientations, the regression coefficients of the path from ITI to learning goals and the path from ITI to performance avoidance goals are not large even though the parameters are statistically significant. In other studies, the regression coefficients of the path from ITI to goals were varied (e.g., the parameters of the path from an incremental theory to learning goals were .59 in Blackwell et al. (2007) and .54 in Jones et al. (2012); the parameter of the path from an incremental view of intelligence to performance goal orientation was -.18 in Dai & Feldhusen (1996)). A similar parameter was found in Chen and Pajare's (2010) study (the regression coefficient of the path from an incremental theory to learning goals was .286). It appears that regression coefficients differ according to differently specified models and scales used to measure the implicit theories of intelligence in each study. The examination of such variations was beyond the scope of this current study.

Conclusions

As the notions of malleability of intelligence gain greater attention and credence in the general education literature and practice and as such notions are adopted in the field of gifted education, the need for sound research using sound measures grows. Based on the data from this study, researchers in the gifted education field can feel confident in using the 6-item implicit theories of intelligence scale to conduct research on implicit theories of intelligence of gifted student populations (grades 5-11).

The data on this sample suggest differences in age groups in beliefs about the malleability of intelligence and also about the relationship between those beliefs and goal setting. These findings are preliminary but warrant future study in conjunction with how the beliefs and goal setting relate to academic achievement. Also, the relationship between genders in the gifted student populations and their implicit theories of intelligence should be investigated by subject domains more specifically.

Findings on this sample imply that gifted students with an entity theory also might exhibit maladaptive behavioral patterns – avoiding challenging tasks, particularly as they become older. Thus, it would be important for practitioners to bear in mind that some gifted students may accept an entity theory which might deter them from challenging themselves, and thus, might pass up opportunities to develop their competence in the domain of their talents. In order to prevent gifted students from adopting an entity theory of intelligence, it would be beneficial for gifted students that practitioners continuously guide gifted students to adopt an incremental view of intelligence.

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Table 1.

Standardized Estimates of CFA

	8-item scale						6-item scale					
Factors	Items	Estimate	S/E	RV	V	Factor Correlation	Items	Estimate	S/E	RV	V	Factor Correlation
ET					1.000	-.845					1.000	-.824
	ET 1	.848	.023	.281			ET 1	.857	.024	.265		
	ET 2	.861	.022	.259			ET 2	.868	.024	.247		
	ET 4	.835	.025	.303			ET 6	.717	.037	.486		
	ET 6	.710	.037	.496								
IT					1.000						1.000	
	IT 3	.900	.018	.190			IT 3	.915	.019	.162		
	IT 5	.803	.027	.356			IT 5	.792	.029	.372		
	IT 7	.831	.024	.310			IT 7	.814	.027	.338		
	IT 8	.793	.028	.371								

	Fit statistics (8-item scale)	Fit statistics (6-item scale)
χ2 (df, p-value)	64.288 (19, <.001)	12.767 (8, .120)
CFI	.965	.994
SRMR	.037	.021
RMSEA(90% CI)	.102 (.075-.130)	.051 (.000-.101)

Note. ET = Entity Theory of Intelligence, IT = Incremental Theory of Intelligence; RV = Residual Variance; V = Variance

Table 2.

Measurement Invariance Tests Across Age and Gender With Gifted Adolescents

Tests	Chi Square	df	LRT	RMSEA	CFI	Δ CFI	SRMR
				Age			
Measurement Invariance							
Configural	22.271	16		0.059	0.993		0.026
Weak	25.031	20	0.599	0.047	0.994	-0.001	0.041
Strong	**31.388**	**24**	**0.174**	**0.052**	**0.991**	**0.003**	**0.050**
Strict	64.392	30	1.047	0.100	0.960	0.031	0.085
Partial Structural Invariance							
Factor Variance	31.213	22	0.045	0.061	0.989	0.005	0.138
Factor Covariance	**33.878**	**23**	**0.103**	**0.064**	**0.987**	**0.002**	**0.148**
Factor mean	54.644	29	0.002	0.088	0.970	0.017	0.176
				Gender			
Measurement Invariance							
Configural	21.820	16		0.056	0.993		0.026
Weak	23.967	20	0.709	0.042	0.996	-0.003	0.036
Strong	**32.295**	**24**	**0.080**	**0.055**	**0.991**	**0.005**	**0.037**
Strict	64.499	30	1.491	0.1	0.961	0.03	0.082
Structural Invariance							
Factor Variance	23.984	22	0.992	0.028	0.998	-0.002	0.036
Factor Covariance	25.948	23	0.161	0.034	0.997	0.001	0.042
Factor mean	**39.838**	**29**	**0.031**	**0.057**	**0.988**	**0.009**	**0.057**

Note. LRT = maximum likelihood ratio test; RMSEA = root mean square error of approximation; CFI = comparative fit index; SRMR = standardized root mean square residual; Bold fonts indicate that the invariance is achieved at the level. Strong measurement invariance across age and gender was achieved. Factor covariance structural invariance across age and factor mean structural invariance across gender were achieved.

Table 3.

Parameters estimates of factor loadings and residuals for the model of the implicit theories of intelligences and goal orientations

Indicator	Factor loadings			Measurement errors		
	Unstandardized	Standard error	Standardized	Unstandardized	Standard error	Standardized
Implicit theories of intelligence						
Entity by						
ET1	1.000	0.000	0.854	0.395	0.056	0.27
ET2	1.006	0.063	0.869	0.35	0.053	0.245
ET6	0.893	0.074	0.715	0.81	0.088	0.488
Incremental by						
IT3	1.000	0.000	0.917	0.197	0.04	0.159
IT5	0.928	0.061	0.791	0.537	0.061	0.374
IT7	0.853	0.053	0.814	0.386	0.046	0.337
ITI by						
Entity	1.000	0.000	0.903	0.196	0.077	0.184
Incremental	1.000	0.000	0.912	0.176	0.070	0.168
Goal orientations						
PAPPG by						
PAPPG1	1.000	0.000	0.545	1.567	0.15	0.703
PAPPG2	1.416	0.171	0.848	0.518	0.113	0.281
PAPPG3	1.416	0.169	0.856	0.482	0.112	0.267
PAPPG4	1.210	0.158	0.684	1.103	0.124	0.532
PAPPG5	1.184	0.149	0.723	0.846	0.098	0.477
PAVOIDG by						
PAVOIDG1	1.000	0.000	0.748	0.744	0.098	0.441
PAVOIDG2	0.850	0.098	0.621	1.086	0.11	0.614
PAVOIDG3	1.076	0.109	0.724	0.991	0.11	0.475
PAVOIDG4	0.963	0.102	0.688	0.977	0.103	0.527
PAVOIDG5	0.884	0.102	0.618	1.193	0.12	0.618
PAVOIDG6	1.207	0.122	0.830	0.621	0.099	0.311
LG by						
LG1	1.000	0.000	0.660	0.590	0.063	0.564
LG2	1.305	0.128	0.821	0.375	0.05	0.326
LG3	1.275	0.136	0.730	0.649	0.074	0.467
LG4	1.062	0.108	0.772	0.349	0.042	0.404
LG5	1.262	0.140	0.715	0.693	0.078	0.488
LG6	1.505	0.164	0.733	0.888	0.101	0.462

Note. ET = Entity theory of intelligence; IT = Incremental theory of intelligence; ITI = Implicit Theories of Intelligence; PAPPG = Performance-approach goal orientation; PAVOIDG = Performance-avoidance goal orientation; LG = Learning goal orientation

Table 4.

Parameters estimates of structural regression, factor variances, factor covariances, and error covariances for the model of the implicit theories of intelligences and goal orientations

Parameters	Unstandardized	Standard error	Standardized
Structural regression			
PAPPG on ITI	-0.023	0.065	-0.026
PAVOIDG on ITI	-0.160*	0.081	-0.154*
LG on ITI	0.273*	0.058	0.377*
Factor variances and covariances			
PAPPG	0.661*	0.152	0.999*
PAVOIDG	0.923*	0.155	0.976*
LG	0.391*	0.075	0.858*
PAPPG with PAVOIDG	0.506*	0.093	0.648*
PAPPG with LG	-0.137*	0.044	-0.270*
PAVOIDG with LG	-0.154*	0.050	-0.257*
Error covariances			
PAPPG2 with PAPPG3	-0.341*	0.089	-0.683*
PAPPG4 with PAPPG5	0.449*	0.093	0.465*
PAVOIDG1 with PAVOIDG6	-0.318*	0.070	-0.468*
PAVOIDG2 with PAVOIDG3	0.382*	0.084	0.368*
LG5 with LG6	0.471*	0.076	0.601*

Note. * for p<.05; ET = Entity theory of intelligence; IT = Incremental theory of intelligence; ITI = Implicit Theories of Intelligence; PAPPG = Performance-approach goal orientation; PAVOIDG = Performance-avoidance goal orientation; LG = Learning goal orientation

Table 5.

Parameters estimates of factor loadings and residuals for the model of the implicit theories of intelligences and goal orientations with age and gender

Indicator	Factor loadings			Measurement errors		
	Unstandardized	Standard error	Standardized	Unstandardized	Standard error	Standardized
Implicit theories of intelligence						
Entity by						
ET1	1.000	0.000	0.859	0.384	0.055	0.261
ET2	0.996	0.061	0.867	0.356	0.053	0.249
ET6	0.883	0.073	0.714	0.814	0.088	0.49
Incremental by						
IT3	1.000	0.000	0.917	0.196	0.039	0.158
IT5	0.928	0.061	0.791	0.537	0.061	0.375
IT7	0.853	0.053	0.813	0.387	0.046	0.338
ITI by						
Entity	1.000	0.000	0.898	0.210	0.075	0.194
Incremental	1.000	0.000	0.917	0.166	0.067	0.160
Goal orientations						
PAPPG by						
PAPPG1	1.000	0.000	0.544	1.57	0.152	0.705
PAPPG2	1.406	0.169	0.840	0.542	0.112	0.294
PAPPG3	1.399	0.167	0.845	0.518	0.11	0.287
PAPPG4	1.231	0.164	0.694	1.074	0.125	0.519
PAPPG5	1.200	0.154	0.731	0.825	0.098	0.465
PAVOIDG by						
PAVOIDG1	1.000	0.000	0.745	0.752	0.098	0.445
PAVOIDG2	0.853	0.098	0.621	1.087	0.11	0.614
PAVOIDG3	1.083	0.110	0.726	0.987	0.109	0.473
PAVOIDG4	0.966	0.102	0.687	0.979	0.103	0.528
PAVOIDG5	0.895	0.103	0.624	1.179	0.12	0.611
PAVOIDG6	1.208	0.123	0.828	0.628	0.098	0.314
LG by						
LG1	1.000	0.000	0.660	0.59	0.063	0.564
LG2	1.305	0.128	0.821	0.375	0.05	0.326
LG3	1.272	0.136	0.728	0.654	0.074	0.47
LG4	1.064	0.108	0.773	0.347	0.042	0.402
LG5	1.262	0.140	0.715	0.693	0.078	0.488
LG6	1.506	0.164	0.734	0.886	0.101	0.462

Note. ET = Entity theory of intelligence; IT = Incremental theory of intelligence; ITI = Implicit Theories of Intelligence; PAPPG = Performance-approach goal orientation; PAVOIDG = Performance-avoidance goal orientation; LG = Learning goal orientation

Table 6.

Parameters estimates of structural regression, factor variances, factor covariances, and error covariances for the model of the implicit theories of intelligences and goal orientations with age and gender

Parameters	Unstandardized	Standard error	Standardized
Structural regression			
PAPPG on			
ITI	0.042	0.066	0.049
Age	0.152*	0.039	0.302*
Gender	-0.109	0.109	-0.067
PAVOIDG on			
ITI	-0.095	0.082	-0.092
Age	0.131*	0.043	0.217*
Gender	0.081	0.133	0.042
LG on			
ITI	0.269*	0.060	0.373*
Age	-0.029	0.029	-0.068
Gender	0.166	0.092	0.122
ITI on			
Age	-0.149*	0.041	-0.255*
Gender	-0.161	0.133	-0.085
Factor variances and covariances			
PAPPG	0.601*	0.140	0.913*
PAVOIDG	0.872*	0.148	0.930*
LG	0.383*	0.073	0.840*
PAPPG with PAVOIDG	0.464*	0.086	0.641*
PAPPG with LG	-0.126*	0.041	-0.262*
PAVOIDG with LG	-0.149*	0.049	-0.259*
Error covariances			
PAPPG2 with PAPPG3	-0.311*	0.089	-0.587*
PAPPG4 with PAPPG5	0.424*	0.094	0.451*
PAVOIDG1 with PAVOIDG6	-0.311*	0.070	-0.453*
PAVOIDG2 with PAVOIDG3	0.381*	0.084	0.368*
LG5 with LG6	0.471*	0.075	0.601*

Note. * for p<.05; *Note.* ET = Entity theory of intelligence; IT = Incremental theory of intelligence; ITI = Implicit Theories of Intelligence; PAPPG = Performance-approach goal orientation; PAVOIDG = Performance-avoidance goal orientation; LG = Learning goal orientation

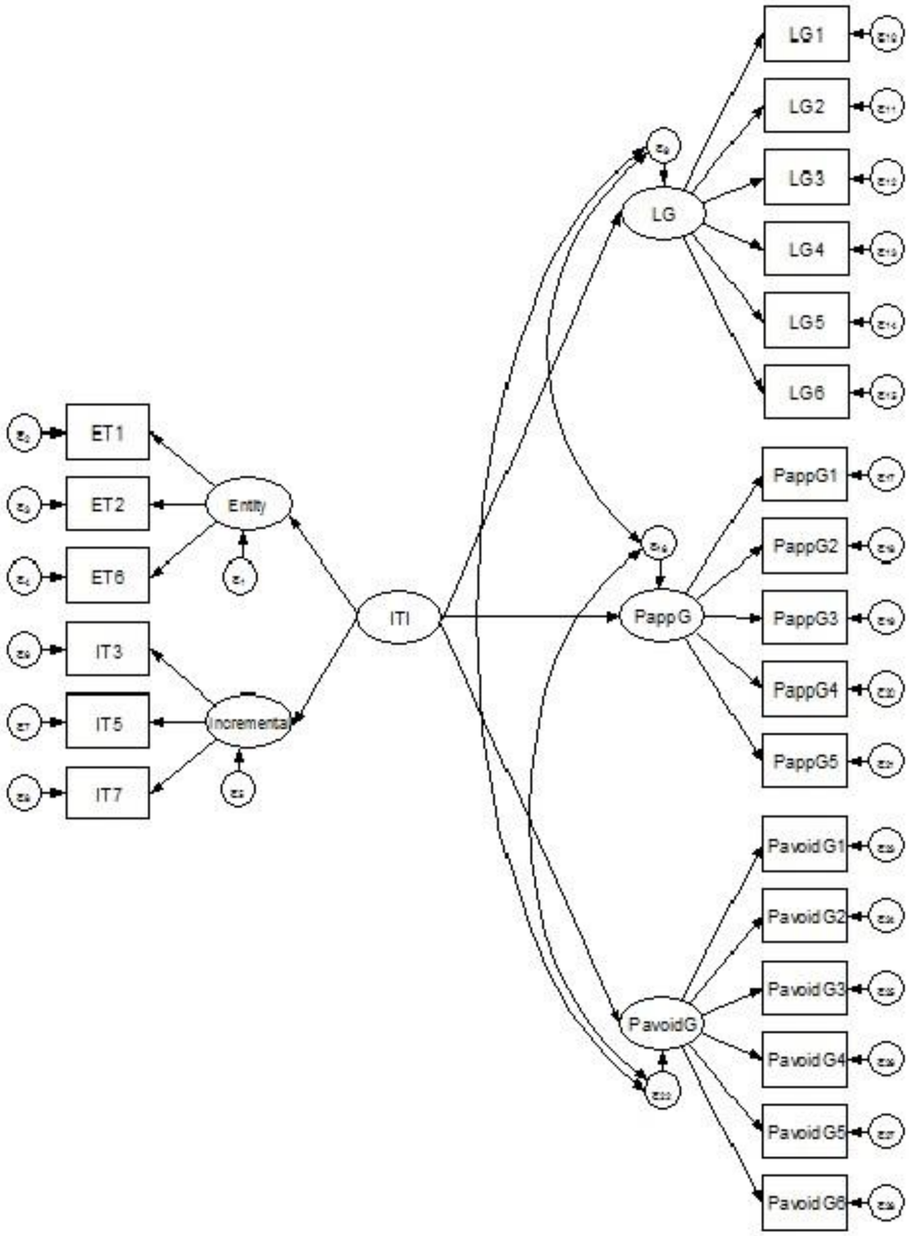

Figure 1. Associations between the implicit theories of intelligence and the goal orientations: Hypothesized model

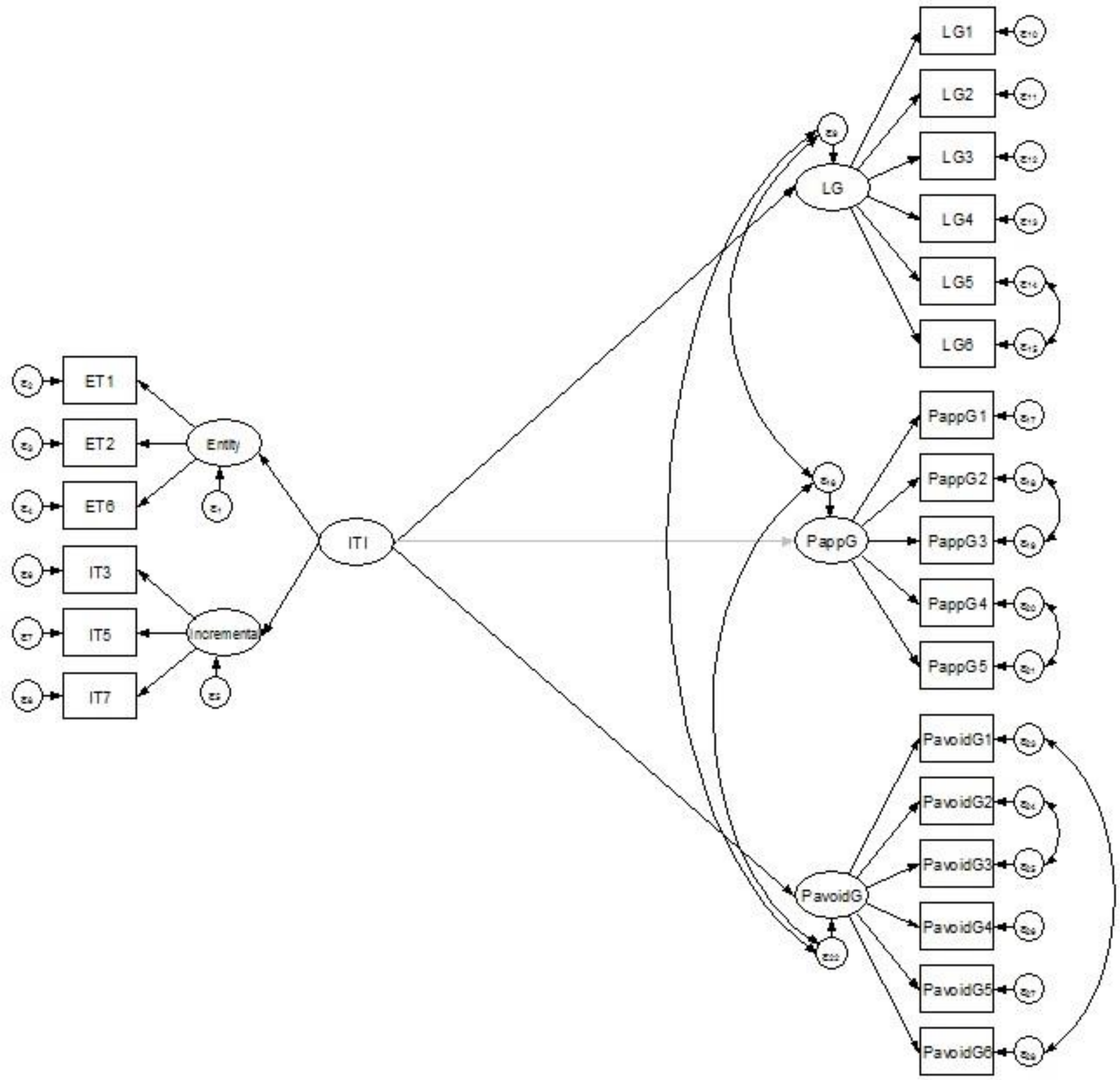

Figure 2. Associations between the implicit theories of intelligence and the goal orientations

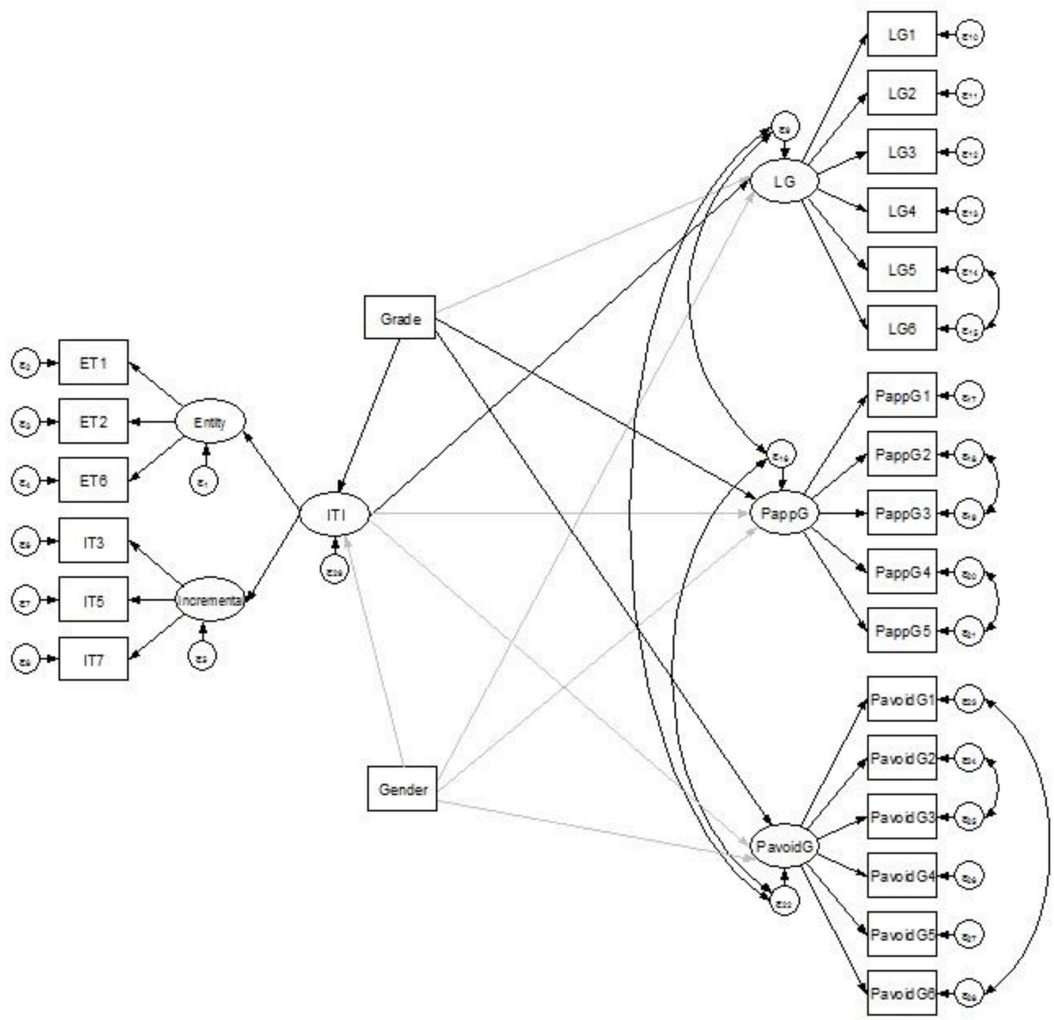

Figure 3. Differences of variables by age and gender groups

Evidence for the Implicit Theories of Intelligence Scale's Measurement Invariance between Non-Identified and Identified Gifted

Park, S., Callahan, C. M., & Ryoo, J. H. (Manuscript ready to submit). Evidence for the Implicit Theories of Intelligence scale's measurement invariance between non-identified and identified gifted.

Abstract

Using samples of general education students (N=75) and gifted students (N=239), the current study 1) examined the factor structure of 6-item and 8-item scales measuring implicit theories of intelligence, which Dweck and her colleagues developed, 2) computed factor reliability of data from the 6-item scale, and then 3) investigated the measurement invariance and structural invariance of the 6-item scale between general education students (not identified as gifted) and gifted students. Results indicated that the 6-item scale was a better fit to the data from the assessed samples of both general education and gifted students than the 8-item scale. The factor reliability of scores for the incremental theory was .847 and for the entity theory was .849. The result of the measurement invariance tests on Dweck's 6-item scale suggests that Dweck's 6-item scale is not biased across two distinct groups, general education students and gifted students. On the other hand, the structural invariance test resulted in a significant mean difference on the incremental theory factor between the two groups.

Keywords: Implicit theories of intelligence, Measurement Invariance, Gifted students, General education students

The importance of implicit theories of intelligence has been highlighted in educational settings because of the relationship between implicit theories of intelligence and student achievement. In the motivation model of implicit theories of intelligence (Dweck & Leggett, 1988), some students believe that intelligence is malleable, indicating an incremental theory of intelligence, while others believe that their ability is fixed, referring to an entity theory of intelligence. Findings of the empirical research on implicit theories of intelligence indicate that an incremental theory of intelligence is associated with higher achievement across the general education population (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2000). Some researchers (e.g., Dweck, 2012; Mueller & Dweck, 1998) also have assumed that labeling a student as “gifted” might lead gifted students to believe in an entity theory of intelligence. Accordingly, Callahan (2012) has noted the particular importance of considering and further researching incremental versus entity theories of intelligence in gifted students.

Research on implicit theories of intelligence, which compares students in the general population to gifted students, is dependent on measuring implicit theories of intelligence accurately in the general education population and in the gifted population. This raises the question of whether existing measures of implicit theories of intelligence yield reliable and valid data for assessing that construct in both the gifted population and the general population. If the scores from existing measure(s) are shown to be reliable and the data gives us evidence of the validity of the use of the measures for assessing the constructs of incremental and entity constructs, researchers may then more confidently examine differences across those groups and also use the measure(s) of the construct in research such as studies that examine effects of interventions directed toward increasing incremental views of intelligence.

To measure implicit theories of intelligence, Dweck (2000) has offered two measures: an 8-item scale for the adult population and a 6-item scale for the student population older than ten years old. However, validity evidence for scores from the 6-item scale with the school-age population of students is scant. The 6-item scale has been used for assessing the construct in the general education student population based on validity evidence provided for scores from the 8-item scale designed for the adult population including college-level students. Further, even though it has been recently reported that the 6-item scale can be used for the gifted student population (Park, Callahan, & Ryoo, in press), there is no evidence on whether the items or sub-factors of the 6-item scale have the same meaning across the two distinct groups of identified gifted students and students in the general education population.

Therefore, in this study we examined the factor structure of the 6-item scale and compared the factor structure of 6-item and 8-item scales measuring implicit theories of intelligence when used with general education and gifted students. The comparison of the factor structure of both of the scales was intended to determine whether the 6-item scale is psychometrically more defensible than the 8-item scale for use with school-age populations of students including gifted students. Next, we calculated reliability estimates for scores on the 6-item scale in both of the groups. Lastly, we investigated whether scores on the 6-item scale are invariant between general education students (not identified as gifted) and gifted students so that we can examine (dis-) similarity between the two groups. These investigations provided additional construct-related evidence for scores from the 6-item implicit theories of intelligence scale for researchers and educators.

Literature Review

A Social-Cognitive Approach to Motivation: The Implicit Theories of Intelligence

Two frameworks. In a social-cognitive approach to motivation, the model of implicit theories of intelligence (Dweck & Leggett, 1988) was built to describe two major goal-oriented behaviors in achievement situations, that is, to explain why some students display mastery-oriented behavior patterns whereas others show helpless behavior patterns in the same achievement situations. According to the motivation model of implicit theories of intelligence, there are two beliefs about ability: an incremental theory of intelligence and an entity theory of intelligence. Students who adopt an incremental theory of intelligence (incremental theorists) believe that their ability is malleable and changeable while those who accept an entity theory of intelligence (entity theorists) believe their intelligence is fixed.

In the face of difficult tasks, incremental theorists tend to choose challenging tasks and make an effort to solve the challenging tasks with persistence. Those students with an incremental theory of intelligence set up goals to learn new and challenging tasks and increase their competence, which reflects the pursuit of learning goals. Also, they try positive strategies to find out how to solve challenging tasks. This indicates mastery-oriented behavior patterns. In contrast, entity theorists are apt to avoid challenging tasks because they do not want to risk a judgment by others or by themselves that they lack ability. Those who adopt an entity theory of intelligence tend to pursue performance goals to document their ability. Their goals in achievement situations are to achieve a good performance evaluation, such as good grades. Further, entity theorists believe that making an effort to achieve a goal is an indicator of low ability. Thus, their belief about ability leads them to avoid difficult tasks and display helpless behavior patterns when they face difficult and challenging tasks.

Measurement of Implicit Theories of Intelligence

Dweck's implicit theories of intelligence scale. Based on a conceptual model of implicit theories of intelligence (Dweck & Leggett, 1988), Dweck and her colleagues developed a scale to measure implicit theories of intelligence. The implicit theories of intelligence scale initially included three items, and then the scale was modified to include eight items (Dweck, Chiu, & Hong., 1995; Levy & Dweck, 1997). The initial version of the scale consisted of three items depicting only an entity theory of intelligence. The 3-item scale was criticized for not including items describing an incremental theory of intelligence factor (Levy, Stroessner, & Dweck, 1998). Accordingly, an 8-item scale, including items assessing both of the frameworks (an entity theory and an incremental theory), was developed.

In the 8-item scale, four items were developed to measure an entity theory of intelligence, and four other items were created to assess an incremental theory of intelligence. Dweck (2000) suggested that the 8-item scale be used with adults and the 6-item scale be used with children older than ten. The core six items of the 6-item scale are the same as six of the items on the 8-item scale, which thus has 2 additional unique items.

Psychometric properties of Dweck's scales. Dweck and her colleagues (Dweck et al., 1995) evaluated the 3-item scale and reported high internal consistency (alphas ranged from .94 to .98 on samples ranging from N= from 62 to 184 across six validation studies) and test-retest reliability (r= .80). In their study, results of factor analysis showed that the three implicit theory scales (intelligence, morality, and world) were statistically independent. As evidence of discriminant validity, they examined a correlation between the 3-item implicit theory scale and other measures, such as Scholastic Aptitude Test scores, and reported that the 3-item scale was statistically unrelated to measures of cognitive ability, self-esteem, optimism, and confidence in other people. However, they did not report specific characteristics of the participants, such as age, in their validation studies.

The 8-item scale, including four entity items and four incremental items, was assessed by Levy and Dweck (as reported in Levy et al., 1998). They reported high internal reliability (alphas ranging from .93 to .95) and test-retest reliabilities (.82 over a 1-week interval and .71 over a 4-week interval). In 1999, Hong, Chi, Dweck, Lin, and Wan evaluated the 8-item scale on a sample of college students. They found negative correlations between responses to the entity items and the incremental items (r= -.81 to -.85), which they presented as validity evidence in that study. The 6-item scale (Dweck, 2000) has been used for general education students based on this report on this structural and discriminant validity evidence of scores from the 8-item scale and the 3-item scale. The only evidence on the validity of the six item scale to date is found in the study of Park et al. (in press).

Uses of Dweck's 6-item scale in studies of general education students. The 6-item scale has been used in research on implicit theories of intelligence in general education student populations (Blackwell et al., 2007; Chen & Pajares, 2010; Jones, Wilkins, Long, & Wang, 2012). Blackwell et al. (2007) examined the impact of implicit theories of intelligence on adolescents' mathematics achievement with data over two years of junior high school and found that an intervention guiding students to view intelligence as malleable led to higher scores on the measure of the incremental theory of intelligence. In their study, they used Dweck's 6-item scale to measure beliefs about general ability and reported an internal consistency estimate of .78 and a test-retest reliability estimate of .77 for the incremental theory factor.

Similarly, Chen and Pajares (2010) examined beliefs about science abilities of 6th graders to understand if an incremental view of science ability is directly or indirectly associated with motivational factors and science achievement. To measure beliefs about science ability, they used a 6-item scale (adapted from Dweck's 6-item scale) to assess beliefs about ability in science. They reported internal consistency estimates of .69 for fixed beliefs and .79 for incremental beliefs. Recently, Jones et al. (2012) used a different adapted 6-item scale to measure 9th graders' beliefs about math ability to examine how an incremental theory of math intelligence, learning goals, positive beliefs about effort, use of positive strategies in math ability, and math scores are related. In all of these studies, the only psychometric properties that researchers reported were reliability estimates.

Measurement of implicit theories of intelligence in gifted students. Several researchers have measured the implicit theories of intelligence of gifted individuals. In their study Dai and Feldhusen (1996) used the measure View of Intelligence. Measuring only entity theory, the statements in the View of Intelligence are items adapted from a scale developed by Dweck and Henderson (1988). They reported an internal consistency estimate of scores on the measure as .74. Also, Feldhusen and Dai (1997) measured the perceptions of ability held by gifted students using six items including both entity and incremental theory statements (e.g., "Reading, thinking, discussion, increase my ability" and "My abilities are fixed and will not change much"). They confirmed the factor structure of the instrument and reported the internal consistency of scores on the measure to be .51.

Hong (2001) developed the Self-Assessment Questionnaire (SAQ) to assess perceptions about domain-general and domain-specific cognitive and motivational constructs at the secondary school level. Hong and Aqui (2004) used five items selected from the SAQ to measure beliefs held by gifted high school students about their general ability and math ability. The internal consistency estimates were .62 for general ability of the domain general SAQ subscale and .88 for math ability of the domain specific SAQ subscale. Esparza, Shumow and Schmidt (2014), who examined the incremental theory of the science ability among gifted 7^{th} graders, used only four items to measure beliefs about the malleability of intelligence (2 items stating an incremental theory of intelligence and 2 items stating an entity theory of intelligence), selected from Aronson, Fried, and Good (2002) and Blackwell et al. (2007). Recently, Park et al., (in press) documented the factor structure of Dweck's 6-item scale with gifted student populations and measurement invariance of the 6-item scale across gender and age.

Various measures have been used to assess beliefs about ability in gifted populations, but little evidence has been presented about the validity of the scores derived from the instruments used to measure implicit theories of intelligence in those studies. Although Park et al., (in press) reported validity evidence of data from Dweck's 6-item scale with gifted students, there was no evidence indicating whether the items or sub-factors of the 6-item scale have the same meaning across the two distinct groups of gifted students and students in the general education population. In order to compare and contrast findings of studies about implicit theories of intelligence of both general education and gifted student populations, researchers would be wise to use measures with evidence of validity and reliability of the scores from both of the groups.

Limitation of Dweck's 6-item Implicit Theories of Intelligence Scale

The limitation of the existing research on the validity of scores from the 6-item scale that Dweck and her colleagues developed is generalizability of the scale. Evidence of generalizability, as one of the aspects considered in establishing construct-related validity, is used to determine whether a scale can be generalized to specified populations (Onwuegbuzie et al., 2007). Although the implicit theories of intelligence scales were designed for use in general population assessment, the gifted population has been highlighted in research on implicit theories of intelligence because some researchers have assumed that labeling students as gifted might lead to the adoption of entity beliefs (Dweck, 2012; Muller & Dweck, 1998).

Since validity of scores on a scale may be influenced by age, gender, ability level, and educational background (Miller, Linn, & Gronlund, 2011), a scale should have score validity evidence with the populations being compared. The Joint Committee on Testing Practices' (2005) Code of Fair Testing Practices in Education supports the claim by suggesting that researchers should provide evidence on the performance of test takers from diverse subgroups and across ages. Although Dweck (2000) has suggested that the 6-item scale be used for students aged ten and older, reports on validity evidence of scores from the 6-item scale with that population of students are scant. The 6-item scale which has been used in studies of general education students is based solely on data from college-level students using a 3 or 8-item scale.

Thus, it is important to confirm the psychometric properties of the 6-item scale with both general education and gifted students and to discern whether the 6-item implicit theories of intelligence scale for students yield differing psychometric evidence than the 8-item scale. Also, it is necessary to test measurement invariance of the 6-item scale between general education and gifted students. Additional construct-related validity and reliability evidence on scores from the 6-item scale will enhance interpretation of research findings.

Measurement Invariance Test Across Distinct Groups

The test of measurement invariance evaluates the degree to which items or sub-factors have identical meaning across groups of test takers, and thus, provides validity evidence for scores on the measure and evidence of construct-irrelevant variance (e.g., group membership) (French & Finch, 2006). According to Schmitt and Kuljanin (2008), scores on a measure are invariant when test takers from different populations who have the identical standing on the construct being measured have the same observed score on the measure. However, a measure is not invariant when scores on the test from two examinees of different populations who are equivalent on the construct differ. (Schmitt & Kuljanin, 2008). When measurement invariance of a test does not exist, differences in observed scores can indicate (a) true group mean differences, and (b) distinctions in the relationship between the construct and the observed score that is not identical across groups (Raju, Laffitte, & Byrne, 2002). Hence, the measurement process must seek to prevent irrelevant variables from influencing scores to avoid undesirable social consequences (Messick, 1989).

Multisample confirmatory factor analysis (MCFA) is a common method to test for measurement invariance. MCFA allows researchers to assess the structure of a measure across groups (Alwin & Jackson, 1981) or across time (e.g., developmentally related questions; Mantzicopoulos, French, & Maller, 2004). This approach enables researchers to compare specific characteristics of the factor model across groups (French & Finch, 2006). In the MCFA model, a series of tests are used to establish that there is invariance across groups (Vandenberg & Lance, 2000). In our study, we analyzed the equality of factor loadings, intercepts, and residuals (Brown, 2006) for the test of measurement invariance and then tested factor variance, factor covariance and the factor mean difference for the structural invariance test. The steps of test for measurement invariance are further described in the Method section.

Method

Participants

Gifted students (Selected as gifted). All student participants in the study were recruited from students who enrolled in a two-week residential summer enrichment program for gifted students (grades 5-11) by sending emails to explain the current study and meeting with parents at registration. Consent forms were collected from parents of these students. Of the 240 participating students, 100 pre-adolescents (rising into grades 5-7, 47 girls), and 139 adolescents (rising into grades 8-11, 85 girls) completed the measures used in this study (total N = 239).

The average of ratings of each student application from two independent raters was used to select students for participation in the summer enrichment program. Both teacher and student input is included in the application. Students responded to two open-ended prompts that focus on problem solving tasks and are rated on a rubric comprised of four factors describing creative products derived from Besemer (1998). Teachers of the students provide ratings of the students on ten items selected from Scales for Rating the Behavioral Characteristics of Superior Students (SRBCSS; Renzulli, Hartman, & Callahan, 1971) and provide responses to four open-ended questions eliciting specific examples of student behaviors that are indicative of giftedness. Students identified as Caucasian American was slightly less than fifty-eight percent of them; African Americans made up 7.0 % of the sample; Asian Americans was 20.6 % of the sample; Latino or Hispanic was the ethnicity reported by 2.2 %; and the remaining students chose “other” or did not self-identify (12.7 %).

General education students (Not selected as gifted). Subjects included 75 minority and/or low income rising 10^{th} to 12^{th} grade students who attended the AP Challenge Program (APCP), a structured intervention program providing academic support to Advanced Placement (AP) students from six predominantly low-income and high-minority mid-Atlantic high schools. Of the sample, 10th graders comprised 41.33% if the sample, 11th grade students comprised 28%, 18.67% were 12th graders, and there was no information about the remaining students’ grade (12%). Students were identified for participation in the program by project staff and local school district counselors and administrators based on four criteria: 1) potential for success in AP courses, but not straight A or B students, 2) not enrolled in AP courses previously, 3) not signed up for

AP classes for the following year at the time of selection, and 4) minority and/or low-income background as determined by their free and reduced lunch status. African Americans comprised 42.67 % of the sample; Asian Americans made up 13.33 % of the sample; Latino or Hispanic was the ethnicity reported by 10.67 %; Pacific Islanders were 8% of the participants; and the remaining students chose "multiracial" (25.33 %).

Instruments

Theory of Intelligence. Dweck's scale (2000) for adults includes eight items: four entity theory statements (e.g., "To be honest, you can't really change how intelligent you are") and four incremental theory statements (e.g., "You can change even your basic intelligence level considerably"). The scale for students older than ten years old is composed of six items: three entity theory and three incremental theory statements. The only difference between Dweck's 8-item scale and her 6-item scale is two items. Two items of the 8-item scale, one from entity theory statements and one from incremental theory statements, are eliminated in the 6-item scale (e.g., "To be honest, you can't really change how intelligent you are." and "You can change even your basic intelligence level considerably."). Respondents rate their agreement or disagreement for each item on a 6-point Likert type scale that ranges from 1 (Strongly Agree) to 6 (Strongly Disagree). Validity and reliability evidence on scores of the 8-item scale has been gathered in several validation studies (Dweck et al., 1995; Erdley & Dweck, 1993; Levy et al., 1998). The eight-item scale was administered to the students on the first day of the programs, and the psychometric properties of the full 8-item scale were compared to those of the embedded 6-item scale.

Data Analyses

First, confirmatory factor analyses were conducted using Mplus to examine the factor structure of the 8-item scale and the 6-item scale (Dweck, 2000) with data from the identified gifted sample and the non-identified general sample. Along with the model chi-square, approximate fit indices including root mean square error of approximation (RMSEA), comparative fit index (CFI), and standardized root mean square residuals (SRMR), were used with the following criteria for good fit: RMSEA < .05, CFI > .95, and SRMR <.08 (Hu & Bentler, 1999) and adequate (or acceptable) fit: .08> RMSEA > .05 (Browne & Cudeck, 1993) and .95 > CFI > .90 (Bentler, 1990).

Second, in order to determine the consistency of the factor structures between general education and gifted students, measurement invariance was tested using Mplus. More specifically, measurement invariance was tested to analyze the equality of factor loadings, intercepts, and residuals, and furthermore, structural invariance was also tested to evaluate factor variance, factor covariance, and factor mean difference (Brown, 2006). The procedures for analysis of measurement invariance include the following steps 1 through step 4. Steps 5 through 7 were used to test for structural invariance analysis.

Step 1. Configural Invariance: Test the invariance of factor structure across groups

Step 2. Loading Invariance: Test that factor loadings are equal across groups

Step 3. Strong Invariance: Test that indicator intercepts are equal across groups

Step 4. Strict Factorial Invariance: Test that indicator error variances are equal across groups

Step 5: Test the equality of factor variances over the loading invariance.

Step 6: Test the equality of factor covariance over the loading invariance.

Step 7: Test the latent mean difference over the intercept invariance.

In order to avoid any ambiguity of statistical inference due to group-specific attributes, the 6-item scale should demonstrate invariance on factor structure, factor loadings, and indicator intercepts across groups. To determine the measurement invariance and structural invariance through the seven steps listed above, we applied the criterion suggested by Cheug and Rensvold (2002) that if the change in CFI is .01 or less, invariance holds.

Finally, we computed the factor reliabilities for both incremental and entity factors using the following formula originally given by Raykov (1997, 2004) with notations in Klein (2011):

$$\hat{\rho} = \frac{\left(\sum_i \hat{\lambda}_i\right)^2 \hat{\phi}}{\left(\sum_i \hat{\lambda}_i\right)^2 \hat{\phi} + \sum_i \hat{\theta}_{ii}}$$

where $\sum_i \hat{\lambda}_i$ is the sum of the estimated unstandardized factor loadings among indicators of the same factor, $\hat{\phi}$ is the estimated factor variance, and $\sum_i \hat{\theta}_{ii}$ is the sum of the unstandardized error variances of those indicators.

Results

Confirmatory Factor Analysis

Confirmatory factor analysis was conducted to investigate whether there was a difference in fit indices of one scale over another with data from both general education and gifted student populations. Results indicated that the 8-item scale was not a good fit in RMSEA (.105), although the scale was a good fit in both CFI (.959) and SRMR (.042).

On the other hand, fit indices of the 6-item scale indicated an acceptable fit in RMSEA (.076), and a good fit in both CFI (.986) and SRMR (.029). In the 6-item scale, the factor correlation between the incremental factor and the entity factor was -.820. When it comes to the factor structure of the 6-item scale, as shown in Table 1, unstandardized estimates of parameters were greater than 0.45, and those were statistically significant ($p< .05$), which indicated that each factor was highly associated with its items within the two factor model. That is, the construct validity evidence was strong with the two factor model for the 6-item scale. The results of CFA were summarized in Table 1 and support the conclusion that the 6-item scale is the better fit for the data with both general education and gifted students.

Measurement Invariance Test

A measurement invariance test was conducted to determine whether the scores on each factor of the 6-item scale have the same meaning in the general education and gifted student groups, that is, scores on the 6-item scale reflect construct-irrelevant variance. As described in the Methods section, in order to examine model invariance, we first fit the model to each group and then constrained model parameters to be equal across two groups. At each step of the test of measurement invariance, we constrained an additional set of parameters to be equal while keeping the constraint(s) in the previous model. As a result, a series of nested models were created. Using the criterion that if the change in CFI is .01 or less then invariance holds (Cheung & Rensvold, 2002), the nested models were evaluated.

The first step of the measurement invariance analysis was to test the configural invariance model which allows researchers to evaluate if the factor structure of a measure has the same meaning across two or more groups of examinees. The configural invariance model was then used as the baseline model when other subsequent invariance models were compared. For the configural model, the 6-item scale was specified as a two-factor model. The first items' loadings of the two-factor model were fixed as 1, and factor means were constrained as 0 for identification in each group. As shown in Table 2, the configural model was confirmed with an acceptable fit (RMSEA= .069) and a good fit (CFI= .989). As the second step of the measurement invariance analysis, the loading invariance model was tested based on the configural invariance model. This step tested that the values of the factor loadings of each item on each factor were identical across groups of respondents. In order to estimate the loading invariance model, the factor variances in the general student group were constrained as 1 while the factor variances in the gifted student group were freely estimated, and the factor means in both groups were constrained to 0. Also, we fixed all loadings to be equal between the two groups while estimating freely all intercepts and error variances. The fit indices of the loading invariance model were in the acceptable range (RMSEA=.055) or in the good range (CFI=.991), and the loading invariance model did not differ from the configural model ($\Delta CFI = -0.002 < 0.01$). Accordingly, we proceeded to the third step of the measurement invariance analysis, testing the strong invariance model.

In the third step, the strong invariance model, researchers evaluated whether latent factor intercepts were the same across groups. For the strong invariance model test, factor variances and means were constrained as 1 and 0 respectively in the general student group while those in the gifted student group were freely estimated. Also, we fixed all factor loadings and item intercepts to be equal across the two groups while freely estimating all error variances. The fit indices of strong invariance model were in either an adequate range (RMSEA =.062) or a good range (CFI = .986). The strong invariance model did not differ from the loading invariance model ($\Delta CFI = 0.005 < 0.01$). Lastly, we examined the strict invariance model in which we tested whether the residuals for each indicator were equivalent across groups. For this step, the factor variance and means were constrained as 1 and 0 respectively in the general student group while freely estimating those in the gifted student group. In addition, we fixed all residual variances to be equal between the two groups. The strict invariance model indicated an inadequate fit in RMSEA (.085) but a good fit in CFI (.968), and the model degraded fit from the strong invariance ($\Delta CFI = 0.018 > 0.01$). Although the fit index of the strict invariance model was inadequate, we could consider the 6-item scale holds the measurement invariance because strong invariance was achieved. These results showed that Dweck's 6-item scale captured the two implicit theories of intelligence factors across the general education and gifted groups equally well. In turn, this means that we can interpret the incremental and entity factors in the same way for both groups. In the Table 2, the results of measurement invariance are shown.

Based on the results of the measurement invariance test, structural invariance of the 6-tiem scale was then assessed using the following three additional models: factor equal variance model, factor equal covariance model, and factor mean model. The factor equal variance and factor equal covariance models were sequentially assessed from the weak invariance model, and the factor mean model created based on the strong invariance was compared with the factor covariance model (Brown, 2006). The factor variance in the gifted student group was fixed to 1, and the result indicated that there was no difference between the factor variance model and the weak invariance model ($\Delta CFI = 0.001 < 0.01$). The factor covariance model fixing the covariance between the entity theory and incremental theory factors in the gifted student group did not differ from the factor covariance model constraining the covariance between the entity theory and incremental theory factors in the general student group. ($\Delta CFI = 0.004 < 0.01$). As a result, we concluded that the factor variances and covariances were invariant between general student and gifted student groups. However, the factor mean model fixing the factor means as 0 in the gifted student group degraded fit from the factor covariance model ($\Delta CFI = 0.014 > 0.01$). When the entity and incremental means were constrained as 0 in the general student group, the entity and incremental means in the gifted student group were 0.068 ($p=0.636$) and 0.323 ($p<.05$). The mean difference on the incremental theory factor between general education and gifted student groups was statistically significant with the mean score of the incremental theory factor in the gifted student group significantly higher than that of the general student group, meaning that general education students in the sample tended to adopt more of an incremental theory of intelligence than gifted students.

Factor Reliabilities of the 6-item Scale

Based on the estimates shown in both Table 1 and Figure 1, factor reliabilities of the data from the suggested 6-item scale were computed for the two factors, the incremental factor and the entity factor, using the formula originally given by Raykow (1997, 2004) with notations in Klein (2011). The factor reliability of scores for the incremental theory of intelligence factor was .847 and for the entity theory of intelligence factor was .849. These two indices of factor reliabilities of the scores from the 6-item scale were within a good range based on the criterion of 0.7 (Nunnally & Bernstein, 1994) and were evidence of convergent validity of scores from the 6-item scale.

Discussion

In the current study, we examined the factor structure of Dweck's implicit theories of intelligence scales using CFA in two different samples: general education students and gifted students. In addition, the measurement invariance across these two samples was investigated using a multi-sample CFA analysis. Results of confirmatory factor analyses suggest that the 6-item scale is a better fit than the 8-item scale, which is consistent with Dweck's recommendation to use the 6-item scale with students older than ten years old and younger than college students. All the fit indices of the 6-item scale (CFI, RMSEA, and SRMR) were either acceptable or good, and factor reliability estimates of data from the 6-item scale were within a good range -- .847 for the incremental theory of intelligence factor and .849 for the entity theory of intelligence factor. The 6-item scale is composed of two latent variables, an incremental theory of intelligence and an entity theory of intelligence, and each latent variable (each factor) consists of three items fitting the recommended criteria for identifiable factors (Rigdon, 1995; Shah & Goldstein, 2006). Thus, given not only other construct-related validity and reliability evidence of the current data from the 6-item scale, but also the theoretical suggestion about the least number of items (Rigdon, 1995; Shah & Goldstein, 2006), the 6-item scale is considered adequate to use for student populations older than ten years old.

The result of the measurement invariance tests on the proposed 6-item scale with gifted students and general education students indicates that Dweck's 6-item scale did not demonstrate significant differences on three invariance tests, the configural, loading, strong invariance test steps, between gifted and general education student populations. That is, the 6-item scale is invariant across the two different student groups. This result implies that Dweck's 6-item scale measures implicit theories of intelligence equally well across the two distinct groups.

However, the result of the structural invariance tests on the 6-item scale shows that there was a group mean difference on Dweck's 6-item scale between general education and gifted student populations. The group mean difference (0.323, $p < .05$) on the incremental theory factor was statistically significant, indicating that general education students in the sample tended to accept more of an incremental theory of intelligence than the students in the gifted sample. The result differs from the earlier finding of no difference in implicit theories of intelligence between identified and non-identified students (Snyder et al., 2013) and raises a question about whether labeling students as gifted really affects the tendency toward an entity theory of intelligence, as some researchers have warned (Dweck, 2002; Dweck, 2012; Mueller & Dweck, 1998).

Limitations

The sample size of the general education student population was far smaller than the sample size of the gifted student population in our study. Also, the general education student group included 10th through 12th graders while the gifted student group ranged from 5th graders to 11th graders. The racial and socio-economic composition of the two groups of students was also very different. The issues of different sample size, different ses and race, and the different range of ages resulted from the selection process for the two research projects. These differences may limit the applicability of the findings of the study. Thus, in future studies, researchers should assess the group mean differences in the implicit theories of intelligence with similar samples in both of the student groups, including students within a more similar range of age, race and SES.

The convenience sampling method for collecting gifted students is another limitation of the study. Students in the gifted student group attended a two-week residential summer enrichment program. Although the student selection procedure of the summer enrichment program follows recommendations in the literature that multiple indicators of giftedness be used to identify gifted students, the identification process for the summer enrichment program differs from the selection process for many programs for the gifted which rely on standardized testing. The different way of identifying students, such as the lack of aptitude test scores in a summer enrichment program, plus the fact that the students were not in their home schools and classrooms limits the generalizability of the gifted student group. In this regard, the findings of the study might not be widely generalizable. Therefore, in future studies, measurement invariance and structural invariance of the 6-item scale should be examined with samples of gifted students identified based on other criteria for giftedness in traditional school settings.

Conclusion

Although some study limitations exist, as Messick (1989) suggested, the findings reflect that the measurement process of the 6-item scale prevented construct-irrelevant variance such as ability level or educational background from affecting scores on the instrument. Hence, the present study is worthwhile in that these results support construct validity evidence of scores from the 6-item scale and suggest that researchers and educators can use the briefer 6-item scale with gifted students and the general population of students. Also, educators can use the 6-item scale to make a decision if mindset interventions are necessary for gifted students. Nevertheless, in order to confirm the group mean differences between the two groups and the impact of the gifted label on the adoption of the implicit theories of intelligence, it would be necessary to continue to examine further such group differences on measures of implicit theories of intelligence.

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Table 1.

Unstandardized & Standardized Estimates of CFA

	8-item scale							6-item scale					
Factors	Items	Uns	S/E	S	S/E	V	F/C	Items	Uns	S/E	S	S/E	V	F/C
ET						1.147	-.807						1.171	-.820
	ET 1	1.000	.000	.859	.020			ET 1	1.000	.00	.868	.021		
	ET 2	.985	.052	.850	.020			ET 2	.988	.054	.862	.021		
	ET 4	.901	.052	.818	.023			ET 6	.842	.062	.696	.034		
	ET 6	.860	.062	.704	.032									
IT						.924							.955	
	IT 3	1.000	.000	.879	.018			IT 3	1.000	.00	.893	.020		
	IT5	.974	.061	.761	.028			IT 5	.941	.063	.747	.030		
	IT 7	.882	.051	.805	.024			IT 7	.846	.052	.785	.027		
	IT 8	1.001	.062	.775	.027									

Note. ET = Entity Theory of Intelligence, IT = Incremental Theory of Intelligence; Uns = Unstandardized estimate; S = Standardized estimate; V = Variance; F/C = Factor Correlation

Table 2.

Measurement Invariance Tests of Dweck's 6-item scale Between General and Gifted students

	Chi sq	Df	p-value	RMSEA	RMSEA 90% CI	CFI	ΔCFI	Pass
Step 1	27.892	16	.0326	.069	[.020, .110]	.989		
Step 2	29.366	20	.0808	.055	[.000, .094]	.991	-.002	Yes
Step 3	38.593	24	.0301	.062	[.020, .097]	.986	.005	Yes
Step 4	37.174	30	<.001	.085	[.056, .113]	.968	.018	No
Step 5	32.945	22	.0626	.056	[.000, .094]	.990	.001	Yes
Step 6	36.797	23	.0341	.062	[.017 .098]	.987	.004	Yes
Step 7	57.404	29	.0013	.079	[.048 .109]	.973	.014	No

Note. Step1: Configural Invariance, Step2: Loading Invariance, Step 3: Strong (Intercept) Invariance, Step 4: Strict Invariance Step5: Test the equality of factor variances over the loading invariance, Step 6: Test the equality of factor covariance over the loading invariance, Step 7: Test the latent mean difference over the intercept invariance

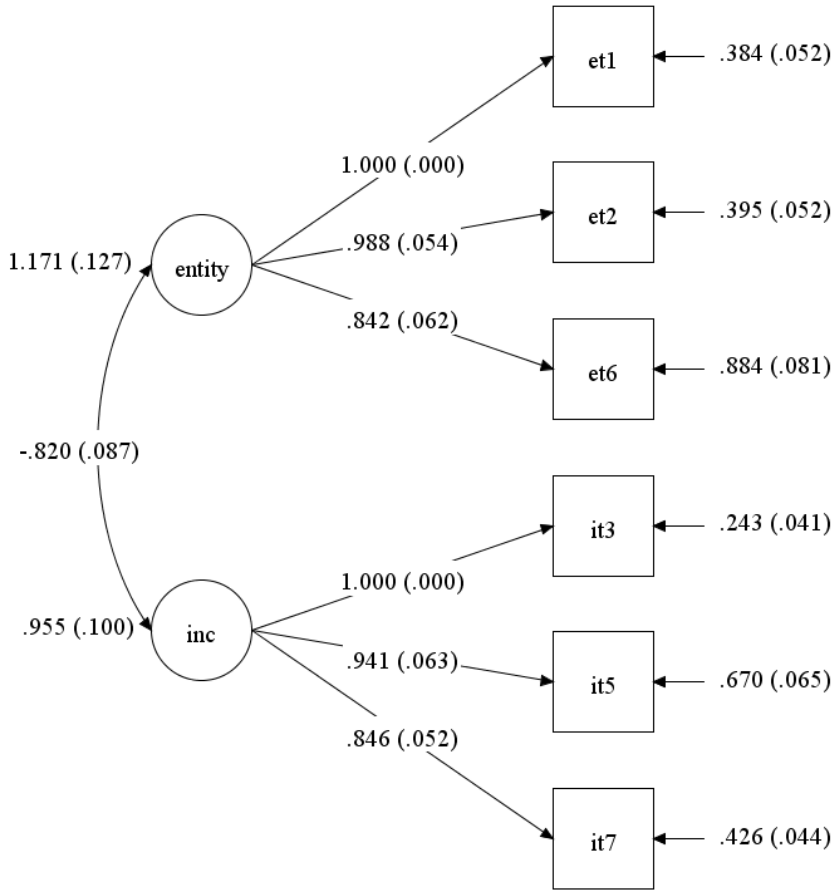

Figure 1. Dweck's 6-item scale with unstandardized estimates of parameters

The Influence of Implicit Theory of Math Intelligence, Achievement Goals, Intrinsic Motivation, Mathematics Achievement, and STEM Career Interest on STEM School Students' Success

According to the U.S. News and World Report, approximately 1 million more science, technology, engineering, and mathematics (STEM) professionals are needed than the U.S. will produce over the next decade unless there are changes in the education pipeline (Holdren & Lander, 2012). Concern about the lack of trained professionals in these disciplines has fueled the creation of STEM high schools designed to support the development of future scientists and engineers (Thomas & Williams, 2010) and to serve academically gifted, science-focused students (Subotnik, Tai, Rickoff & Almarode, 2010). Within the specialized environments of STEM high schools, the experiences gifted students gain from challenging coursework and opportunities to be involved in the processes associated with STEM may influence their interest in and intrinsic motivation to pursue STEM areas (Bruce-Davis et al., 2014; Tofel-Grehl & Callahan, 2014). However, the specialized environment of STEM schools where students face challenging course materials and competition from equally talented peers might deter some of these students from maintaining interest and confidence in STEM areas and succeeding academically (Seaton, Marsh, & Craven, 2010; Tofel-Grehl & Callahan, 2014).

Students' lack of confidence may be further exacerbated by the phenomenon known as the Big Fish Little Pond effect wherein some high-achieving students tend to score low on measures of self-concept when placed in highly selective school programs (BFLPE; Marsh & Parker, 1984; Seaton, Marsh, & Craven, 2010). Researchers found low self-concept ultimately leads to low performance (Marsh & Martin, 2011; Valentine, DuBois, & Cooper, 2004) and low intrinsic motivation (Cokely, Bernard, Cunningham, & Motoike, 2001; Seaton, Marsh, & Craven, 2010). Consistent with this theory, some STEM school students in a study by Tofel-Grehl and Callahan (2014) reported feeling external pressure to achieve which is one of the factors to undermine intrinsic motivation (Reeve & Deci, 1996; Ryan & Deci, 2000).

Another rationale for student success or lack of success in challenging academic situations can be found in the research on implicit theory of intelligence which explains why some students successfully achieve and grow in the face of academic challenge whereas others do not. According to Dweck and Leggett (1988), an individual's learning process is influenced by one's implicit theory of intelligence. This individually held belief about the nature of intelligence consists of two frameworks: an incremental theory in which one believes that intelligence can be developed through effort, and an entity theory in which one believes that intelligence is fixed (Dweck & Leggett, 1988; Yeager & Dweck, 2012). In the motivation model of implicit theory of intelligence (Dweck & Leggett, 1988), an implicit theory of intelligence shapes students' achievement goals. In difficult academic situations, students holding an incremental theory tend to pursue learning goals, which guide students to increase their effort to improve their performance and learn something new from challenging tasks; in contrast, students with an entity theory are apt to pursue performance goals, in which students tend to avoid any activity that might indicate a lowered level of ability, including challenging tasks. Consequently, they might miss opportunities to improve their academic achievement. Also, researchers (e.g., Grant & Dweck, 2003; Haimovitz, Wormington & Corpus, 2011) have revealed that an adoption of an incremental theory and learning goal pursuits are associated with maintaining intrinsic motivation.

Although the current literature about the implicit theory of intelligence indicates that an incremental theory of intelligence and learning goals are core components of successfully achieving and maintaining intrinsic motivation in challenging academic situations, there is little research on whether the relationship between implicit theory of intelligence and achievement goals has an impact on gifted students' learning motivation and achievement. Also, some researchers (Elliot, 1999, 2005; Middleton & Midgely, 1997; Pintrich, 2000) separate performance goals into performance-approach (i.e., striving to outperform others or appear competent) and performance-avoidance goals (i.e., striving to avoid doing worse than others or appearing incompetent) (Elliot & Moller, 2003). However, the distinction between the approach and avoidance aspects is not separated in the motivation model of implicit theory of intelligence (Dweck & Leggett, 1988).

In selective school programs such as STEM high schools, acceptance of an incremental theory of intelligence and learning goals might be core components related to the achievement of gifted students and their continued interest in STEM areas. Notably, given that successful achievement in a domain of mathematics (Wang, 2013b; Sadler, Sonnert, Hazari, & Tai, 2012) and intrinsic motivation (Christensen, Knezek, & Tyler-Wood, 2015) have been found to be critical for maintaining interest in STEM careers, it is significant to examine how the implicit theory of intelligence is associated with achievement goals (including learning, performance-approach, performance-avoidance goals), intrinsic motivation, mathematics achievement, and STEM career interests of gifted students in STEM schools. The examination may shed light on the complex interrelationships across these variables, their influence on the achievement of gifted students in STEM schools, and motivation to pursue STEM careers. Also, an investigation into differences on these factors across gender and age is meaningful because some researchers report gender gaps in STEM areas (Sadler et al., 2012), as well as age differences in the implicit theory of intelligence (e.g., Dai & Feldhusen, 1996) and intrinsic motivation (e.g., A. W. Gottfried, Cook, Gottfried, & Morris,, 2005).

Literature Review

STEM Schools

Types of STEM high schools. STEM schools are specialized schools with specific emphases on one or more of the areas of science, mathematics, engineering, and technology (Subotnik et al., 2010). One of the purposes of STEM schools is to serve academically gifted students with talents in mathematics and science (Subotnik et al., 2010). There are different types of STEM school structures including school-within-a school programs, pullout programs, stand-alone schools, residential schools, and university-based schools (Lundgren, Laughen, Lindeman, Shapiro, & Thomas, 2011). Admission to STEM schools is either selective or open to all (Tofel-Grehl & Callahan, 2014). In general, STEM high schools with selective admission processes evaluate students based on standardized test scores such as SAT or ACT, middle school grades, and teacher recommendations. The focus of my study will be gifted students who are in full-day STEM high schools with selective admission processes designed to meet the needs of gifted students with talents in mathematics and/or science whose learning levels are beyond their age-level peers.

STEM high school culture (Environment). Critical features that have been identified as important for the success of gifted and talented students include: a community of intellectual peers, a challenging but engaging and supportive environment, and an environment that fosters independence in learning (National Association for

Gifted Children, 2010). These features of high quality education of gifted and talented students are found in specialized STEM schools. Bruce-Davis et al. (2014) indicated that STEM schools create a challenging and engaging environment for students' learning and also inspire students to have an identity characterized as "smart" (p. 289). Tofel-Grehl and Callahan (2014) reported common characteristics of different types of STEM schools, which included a culture focused on intellectual pursuits and being surrounded by like-minded peers, a high value on research, a learning environment focused on inquiry, and the importance of personal responsibility and independence in learning.

In order to create a challenging and engaging environment, STEM schools pursue the overarching goal of providing "excellent educational opportunities for students within STEM discipline classrooms" (National Consortium for Specialized Secondary Schools of Mathematics, Science, and Technology [NCSSSMST], 2011). In practice, STEM school students are provided opportunities to take advanced courses such as Advanced Placement courses and college-level courses and to pursue research in real world settings (Olszewski-Kubilius, 2010; Pfeiffer, Overstreet, & Park, 2010). Within such a specialized environment, school administrators, teachers and students perceived STEM schools as supportive and academically focused, but not competitive; however, students still reported tremendous pressure to perform stemming from parents and from particularly high teacher expectations (Tofel-Grehl & Callahan, 2014).

Additional pressure may stem from the Big Fish-Little Pond effect (BFLPE; Marsh & Parker, 1984) wherein students compare their own achievement to the achievement of other peers in classroom, using the class average or school average as a frame of reference. This process tends to have adverse effects on the academic self-concept of high achieving students in classrooms with equally able peers or within selective school systems (e.g., Craven, Marsh, & Print, 2000; Marsh et al., 2008). When this process results in a poor self-concept, the result is likely a negative impact on academic performance (Marsh & Martin, 2011), educational aspirations (Nagengast & Marsh, 2012), and affective reactions such as school anxiety (Zeidner & Schleyer, 1998). Hence, although gifted students benefit from the environment of learning to cooperate with their like-minded peers (Tofel-Grehl & Callahan, 2014), some gifted students may respond negatively to pressure to perform well academically in comparison to peers, and thus, might lose interest in STEM areas (Reeve & Deci, 1996; Ryan & Deci, 2000). Accordingly, it is important to understand which factors lead gifted students to successfully achieve in the specialized environment of STEM schools and maintain interest in STEM areas.

Conceptual Framework for Investigating Factors Affecting STEM Career Interest

I have created a conceptual framework to explain which factors lead some gifted students to successfully achieve and maintain interest in STEM areas within the same challenging academic situations in which others with equally intellectual abilities underachieve and lose interest. The model I propose includes the relationships between Dweck's implicit theory of intelligence, achievement goals, intrinsic motivation, and mathematics achievement and how the relationships among those factors affect STEM career interest of gifted students in STEM high schools.

Dweck's implicit theory of intelligence. Based on Dweck's social-cognitive theory of motivation, the implicit theory of intelligence has been identified as a significant factor related to the development of student abilities and improvement of academic achievement in general educational settings (Dweck & Leggett, 1988; Dweck, 2012). In this motivation model, achievement goals play critical roles in improving academic achievement acting as mediating factors between implicit theory of intelligence and academic performance (Dweck & Leggett, 1988; Blackwell, Trzesniewski, & Dweck, 2007).

In the face of academic challenge, the incremental belief about intelligence leads students to pursue learning goals, which leads them to choose difficult and challenging tasks and learn something new from the challenging tasks with persistence, indicating a mastery-oriented behavior pattern. As a result, incremental theorists are more likely to improve their academic performance. In contrast, entity theorists tend to pursue performance goals, which may lead students to avoid demonstrating a lack of ability while deciding to give up challenging tasks in the face of academic difficulty, thus missing opportunities to improve their academic achievement by showing a helpless-oriented behavior pattern.

Achievement goals. In Dweck's implicit theory of intelligence (Dweck & Leggett, 1988), achievement goals are one of the core components used to explain the learning process. Dweck and Leggett (1988) noted the dichotomous framework distinguishing learning goals and performance goals to explain how goal orientations mediate the relationship between implicit theories of intelligence and academic achievement. In this dichotomous framework, learning goal pursuers refer to individuals who are focused on improving their skills, mastering materials, and learning new things; they make extended efforts to learn something new. On the other hand, performance goal pursuers focus on maximizing favorable evaluations of their competence and minimizing negative evaluations of competence. As a result, they might avoid challenging tasks for positive evaluations of competence. Early studies in this area indicated that learning goals tended to lead to a number of positive processes and outcomes, while performance goals sometimes had negative consequences, sometimes had no consequences, and sometimes had positive consequences (Elliot & Harackiewicz, 1994; Miller & Hom, 1990). Thus, researchers (Elliot & Harackiewicz, 1996; Elliot, 1999, 2005) began to separate performance goals into two different types under the trichotomous framework.

In the trichotomous framework, focusing on learning, performance-approach, and performance-avoidance goals (Elliot, 1999, 2005) the approach and avoidance aspects of performance goals are highlighted due to the different impact on students' outcomes (Elliot & Harackiewicz, 1996). Performance-approach goals refer to the students' desire to demonstrate competence and outperform others. Performance-avoidance goals involve the desire to avoid looking incompetent. Researchers (Elliot, 1999; Elliot & Harackiewicz, 1996; Elliot & Church, 1997; Middleton & Midgely, 1997; Pintrich, 2000) began to split the effects of these two kinds of performance orientations and found evidence that performance-approach goals can be positively related with outcomes such as grades, whereas the impact of performance-avoidance goals is nearly always negative. Also, researchers have documented that performance avoidance goals predict lower intrinsic motivation while learning goals are positively related with intrinsic motivation (e.g., Barron & Harackiewicz, 2001; Elliot & Church, 1997; Grant & Dweck, 2003; Harackiewicz, Barron, Carter, Lehto, & Elliot, 1997; Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000). The more specific relationships to outcomes led me to adopt the trichotomous framework to measure goal orientations in the present study.

Intrinsic motivation. According to Ryan and Deci (2000), there are two distinct types of motivation, intrinsic motivation and extrinsic motivation. When individuals are intrinsically motivated, they do activities for their own sake and out of interest in the activity. When extrinsically motivated, individuals do activities for instrumental or other reasons, such as external prods, pressures, or rewards (Ryan & Deci, 2000; Sansone & Harackiewics, 2000). Intrinsic motivation is considered critical because this motivational component is not only related to academic performance (A. E. Gottfried, Marcoulides, Gottfried, Oliver, & Guerin, 2007; Lepper, Corpus & Iyengar, 2005), but also associated with transforming early mathematical abilities into adult creativity (Subotnik, Pillmeier, & Jarvin, 2009). Students with high intrinsic motivation are likely to perform better academically than those with low intrinsic motivation (e.g., A. W. Gottfried, Gottfried, Bathrust, & Guerin, 1994; A. W. Gottfried et al., 2005; A. E. Gottfried et al., 2007; Haimovitz et al., 2011).

Also, intrinsic motivation has been identified as an important predictor of the pursuit of STEM majors and STEM careers (Christensen et al., 2015; Wang, 2013a). According to Christensen et al. (2015), students' intrinsic motivation is the most important factor influencing interest in STEM careers. In addition, Wang (2013a) revealed that interest in STEM has the strongest association with students' actual choice of a STEM field of study. Hence the influence of intrinsic motivation on academic achievement and STEM career interest is warranted. In the same vein, intrinsic motivation is found to be associated with learning goals (e.g., Barron & Harackiewicz, 2001; Grant & Dweck, 2003; Harackiewicz et al., 2000) and an incremental theory of intelligence (Aronson, Fried & Good, 2002; Cury, Elliot, Da Fonseca & Moller, 2006; Haimovitz et al., 2011).

Mathematics achievement. High math achievement is predictive of a college student's intent to major in STEM or interest in STEM careers (Hill, Corbett, & St. Rose, 2010; Wang, 2013a, 2013b; Sadler et al., 2012). Wang (2013b) found that 12th-grade math achievement was directly correlated with intent to major in STEM. Sadler et al. (2012) also found that high grades in middle school math courses were associated with increasing intentions to pursue STEM careers over the course of the high school years even if students did not show an interest in a STEM career at the start of high school. Thus, I will examine how implicit theories of intelligence, goal orientations, and intrinsic motivation are related to gifted students' mathematics achievement, and subsequently, how their mathematics achievement is associated with STEM career interest.

Implicit Theory of Intelligence, Goals, and Intrinsic Motivation

In general, incremental theorists tend to adopt learning goals while entity theorists tend to accept performance goals (Dweck & Leggett, 1988; Dweck, 2012). Learning goal pursuers are found to engage in deeper, more self-regulated learning strategies, have higher intrinsic motivation, and perform better, particularly in the face of challenges or setbacks (e.g., Barron & Harackiewicz, 2001; Elliot & Church, 1997; Grant & Dweck, 2003; Harackiewicz et al., 1997; Harackiewicz et al., 2000). However, the findings of the significant effect of learning goals on academic performance are dependent on the outcome measured. For instance, in Barron and Harackiewicz's study (2001), they revealed that learning goals were the strongest predictor of interest in a math activity while performance goals were the strongest predictor of performance in the math activity.

Also, data suggest that an incremental theory of intelligence is related to higher levels of intrinsic motivation whereas an entity theory of intelligence is associated with lower levels of intrinsic motivation (Aronson, Fried & Good, 2002; Cury, Elliot, Da Fonseca & Moller, 2006, Haimovitz et al., 2011). In addition, research indicates that intrinsic motivation is related to academic performance (e.g., A. W. Gottfried et al., 2005; Haimovitz et al., 2011) and a variety of adaptive learning behaviors such as persistence, preference for challenge, and engagement in deep conceptual learning (e.g., Boggiano, 1998; Otis, Grouzet & Pelletier, 2005). However, little is known about the relationships between the implicit theories of intelligence, goal orientations, intrinsic motivation, and their combined relationships and effect on academic achievement.

Implicit Theory of Intelligence, Goals, and Intrinsic Motivation in Gifted Students

In terms of the implicit theory of intelligence of gifted students, inconsistent findings have been reported. Some researchers found that gifted students tended to hold an incremental theory of intelligence (Dai & Feldhusen, 1996; Feldhusen & Dai, 1997; Esparza, Shumow & Schmidt, 2014; Park, Callahan, & Ryoo, in press). However, Hong and Aqui (2004) found no significant differences in the beliefs about general ability between high school students identified as academically gifted in math, those creatively talented in math, and those not identified as gifted. All groups exhibited incremental beliefs about general ability. The inconsistent findings might be associated with students' age. Although gifted students tended to adopt an incremental theory of intelligence, when the incremental theory of intelligence was compared between younger students and older students, older students were apt to adopt a higher entity theory of intelligence (a lower incremental theory of intelligence) than younger students (Ablard & Mills, 1996; Dai & Feldhusen, 1996; Park et al., in press).

Empirical research comparing goal orientations of gifted students and non-identified peers also presents two distinct findings. Baldwin and Coleman (2000) indicated that high-achieving academically talented students tend to pursue learning and performance-approach goals significantly more often than low-achieving academically talented students. However, in other studies, researchers did not find a difference on goal orientations between gifted and non-gifted students (Meier, Vogl, & Preckel, 2014; Preckel, Goetz, Pekrun, & Kleine, 2008; Ziegler, Heller, & Broome, 1996). As to whether achievement goals change across age, Park et al. (in press) found that older gifted students are more likely to hold the belief that their intelligence is fixed and are more likely to pursue performance approach goals and performance avoidance goals than younger gifted students.

When it comes to intrinsic motivation of gifted students, academically gifted students tend to have higher intrinsic motivation than their average-ability peers (e.g., A. E. Gottfried & Gottfried, 1996; A. W. Gottfried et al., 2005; A. E. Gottfried, et al., 2007). Across middle childhood through late adolescence, intellectually gifted students had significantly higher academic intrinsic motivation compared to their average cohort peers (A. E. Gottfried & Gottfried, 1996). A. W. Gottfried et al. (2005) found that gifted adolescents had significantly greater academic intrinsic motivation during their middle childhood years than a comparison group of average learners. More specifically, 79% of gifted adolescents had higher intrinsic motivation during the middle childhood years compared to 21% for the average-ability comparison group. A. E. Gottfried and Gottfried

(2004) concluded that in light of the research on academic intrinsic motivation, from elementary school years through late adolescence, students identified as intellectually gifted have greater academic intrinsic motivation than their average-ability peers. Nevertheless, researchers identified a general decline in academic intrinsic motivation as gifted students become older (e.g., A. E. Gottfried, Fleming, & Gottfried, 2001; A. W. Gottfried et al., 2005). Also, A. E. Gottfried, et al. (2007) investigated the longitudinal relationship between academic intrinsic math motivation and math achievement with students from ages 9 through 17. They found that on average, both math motivation and achievement decreased over time. This study revealed that low math achievement is a significant contributor to the developmental decline in intrinsic math motivation from childhood through adolescence.

Gender Gaps

Interests in STEM careers. In spite of the effort to support the development of future scientists, women still persist at lower rates in STEM areas than their male counterparts (e.g., Blickenstaff, 2005; National Science Foundation, 2011). According to Sadler et al. (2012), at both the beginning and the end of high school, boys with STEM career intentions outnumber girls with these intentions. At the end of high school, male college-going students were three times more likely to plan to pursue STEM-related careers than their female counterparts-- not in the “science” but in the “engineering” part of STEM. Of the females who were interested in STEM careers at the start of high school, 45% were still interested at the end of high school, whereas 70% of the males maintained interest (Sadler et al., 2012). Female students lag behind male students in both recruitment to, and retention in, STEM career interests. Thus, it is necessary to examine if there are differences on implicit theories of intelligence, achievement goals, intrinsic motivation, mathematics achievement and interest in STEM careers in the conceptual model across gender, and then, if there are differences on those factors between females who show a high level of interest in STEM careers and females who show a low level of interest in STEM careers.

Implicit theory of intelligence. Inconsistent findings relative to gender differences on implicit theory of intelligence have been reported across several studies (Dai & Feldhusen, 1996; Hong & Aqui, 2004; Park et al., in press). Although gender was not significantly associated with an incremental theory of intelligence or any type of goal orientation (learning, performance-approach, and performance avoidance) (Park et al., in press) and gender differences were not found on beliefs about general intellectual ability (Hong & Acqui, 2004), Chen and Pajares (2010) reported that 6th grade boys held slightly higher incremental views of science ability than did girls. Thus, an investigation of differences on those factors in the conceptual model across gender is warranted.

Current study

Math achievement (Sadler et al., 2012; Wang, 2013b) and intrinsic motivation (Christensen et al., 2015) are considered critical to maintain interest in STEM careers. Based on literature about Dweck's implicit theory of intelligence in general education settings, an incremental theory of intelligence and learning goals play important roles in succeeding academically in challenging academic situation (e.g., Blackwell et al., 2007) and being intrinsically motivated (e.g., Haimovitz et al., 2011). Also, as gifted students become older, they tend to move toward an entity theory of intelligence, pursue performance goals over learning goals (Ablard & Mills, 1996; Dai & Feldhusen, 1996;

Park et al., in press) and show a decline in intrinsic motivation (e.g., A. E. Gottfried et al., 2001; A. W. Gottfried et al., 2005). In addition, gender gaps in STEM workforce (e.g., Blickenstaff, 2005; National Science Foundation, 2011) continue. Thus, I intended to investigate how implicit theories of intelligence of gifted students in STEM schools are related to achievement goals, intrinsic motivation, math achievement, and STEM career interest to identify factors that influence gifted students' performance and the preparation of future professionals in the STEM workforce. Particularly, the present study focused on math-oriented motivational disposition because math achievement (e.g., Wang, 2013b) is found to be critical to maintain interest in STEM disciplines and adolescents might have domain-specific beliefs about ability (Stipek & Gralinski, 1996). Finally, I planned to examine how the relationships among the above variables differ across gender and age.

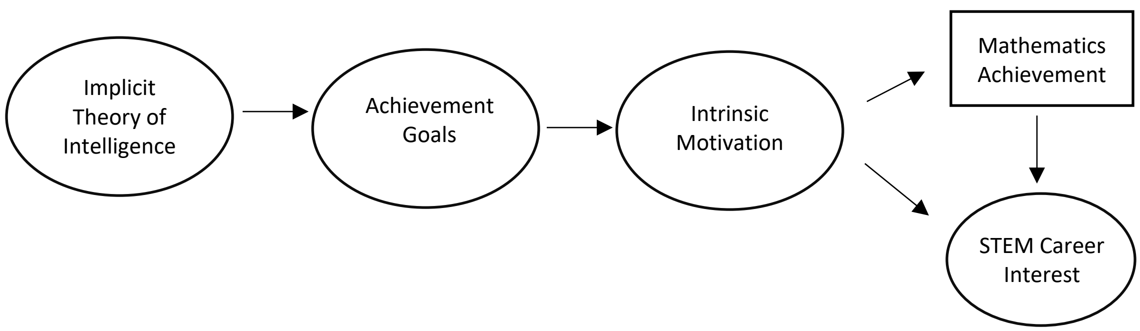

Figure 1. Conceptual Model.

Research Questions

First, what are the relationships among the implicit theories of math intelligence, math-oriented achievement goal orientations, math-oriented intrinsic motivation, and math achievement in gifted students attending STEM high schools?

Second, taking into account the relationships described in Question 1, how are factors that are used to explain motivation (the implicit theories of math intelligence, math-oriented achievement goal orientations, and math-oriented intrinsic motivation) and gifted students' math achievement associated with STEM career interest?

Third, how do the relationships described in Question 1 and 2 vary across gender and age from 9th to 12th grade?

Based on the aforementioned theoretical assumptions and previous research findings, the hypotheses for the study follow:

First, the mathematics achievement of academically gifted high school students focused on math and science are accounted for by three separate, but correlated variables. Therefore, students' incremental theory of intelligence, learning goals, and intrinsic motivation are positively correlated with mathematics achievement. A low incremental theory of intelligence (or high entity theory), performance-avoidance goals, and low intrinsic motivation are negatively correlated with mathematics achievement. Furthermore, an incremental theory of intelligence are positively related with learning goals and intrinsic motivation but are negatively related with performance-avoidance goals.

Second, interest in STEM careers among academically gifted high school students focused on math and science are accounted for by four separate, but correlated variables. A high incremental theory of intelligence, high learning goals, high intrinsic motivation and high mathematics achievement are positively correlated with interest in STEM careers while a low incremental theory of intelligence (or high entity theory), performance-avoidance goals, low intrinsic motivation and low mathematics achievement are negatively correlated with interest in STEM careers.

Third, academically gifted, science-focused students who are older have lower incremental theory of intelligence, learning goals, intrinsic motivation, and interest in STEM careers than younger students. Also, female students have lower interest in STEM careers than male students. Female students with low interest in STEM careers lower incremental theories of intelligence, learning goals, intrinsic motivation, and math achievement than both male and female students with high interest in STEM careers.

Method

Participants

Participants were 144 students from grades 9-12 attending a full-day STEM high school with a selective admission process in the state of Virginia. All students in the school were invited to participate. Although all participants provided complete information on demographics, some participants did not respond to actual survey items at all (n= 12). The final sample was 132 students with complete data on the demographics (57 (43.2 %) male, 75 (56.8%) female, 37.1% 9th graders, 23.5% tenth graders, 22% eleventh graders, and 17.4% twelfth graders). Students in this STEM high schools were selected based on the following criteria: math and verbal scores from the school admission test, ratings of responses to essay prompts, Grade Point Averages (GPA) in grades 7 and 8 including a core subject GPA and a math/science GPA, and teacher recommendations. Most participants identified as Asian/Asian American (47.7 %), followed by White (40.2 %), African American (8%), Hispanic or Latino (2.3%), or Other (9.1%). Students were recruited by emails to parents of students.

Procedure

Consent/Assent forms from parents and students were obtained electronically. At the first stage of data gathering, I emphasized the fact that student participation in the survey was voluntary and that students could withdraw from the study anytime without any penalty. A motivational questionnaire assessing implicit theory of math intelligence, math-oriented achievement goals, math-oriented intrinsic motivation, and STEM career interest and asking personal information (e.g., gender) and mathematics grades was distributed to parents of potential participants using an online survey tool on the 1st of May, 2016. If the parents agreed to allow their child to participate in the survey, they provided their electronic signature and were then asked to let their child complete the survey on their computers. The questionnaire required approximately 20 minutes to complete. Two weeks after the first distribution of the survey, the second stage of data gathering was initiated with a reminder about the survey sent to parents of potential participants. The reminder included an announcement that 20 participants would be provided $10 e-gift cards through prize drawings. One week after the first reminder, a second reminder about the survey was sent to parents of students with a notice that 40 e-gift cards would be provided for participants. The survey responses that were collected across the four weeks from May 1, 2016 to May 29, 2016 were used in the data analyses.

Measures

The survey completed by participating students consisted of the self-report measures described below.

Theory of math intelligence. Although Dweck's original scale refers to abilities in general, Stipek and Gralinski (1996) posited that adolescent students may have subject-specific ability beliefs. Therefore, items to measure the implicit theories of math intelligence were adapted from the 6-item Implicit Theories of Intelligence Scale (Dweck, 2000) for students older than ten years old. On the scale consisting of the adapted six items, students were asked to specifically consider their abilities in mathematics rather than their general intellectual abilities. Items were worded to focus students on the subject of mathematics because mathematics performance was found to be a critical factor influencing STEM career interest. The 6-item scale consists of three entity theory statements (e.g., You have a certain amount of mathematics intelligence, and you can't really do much to change it) and three incremental theory statements (e.g., No matter who you are, you can significantly change your mathematics intelligence level). Respondents rated their agreement or disagreement for each item on a 6-point Likert type scale that ranged from 1 (Strongly Agree) to 6 (Strongly Disagree). In this study, in order to apply structural equation modeling to the hypothesized model in Figure 2, I reverse-scored items in the incremental theory factor, so that a high score (6) of the implicit theories of intelligence scale implied a strong agreement with an incremental theory and a low score (1) represented an entity theory, as in Blackwell et al. (2007). In the previous studies, alpha coefficients of scores from Dweck's 6-item scale ranged from .77 to .88 (e.g., Blackwell et al., 2007; Park et al. in press). Structural validity evidence of data from Dweck's 6-item scale supported the use of the 6-item scale with gifted students (Park et al., in press). The internal consistency estimates of scores from the present study were .91 for an entity theory and .91 for an incremental theory.

Math-oriented learning, performance-approach, and performance-avoidance goals. Items related to a learning goal orientation, a performance-approach goal orientation, and a performance-avoidance goal orientation were selected and adapted from the Patterns of Adaptive Learning Survey (PALS; Midgley, Kaplan, Middleton, & Maehr, 1998) to reflect mathematics domain specificity. Items were adapted to focus students on the subject of mathematics and to reflect goals oriented toward success in the subject of mathematics. Students rated their agreement with each item on a 6-point Likert type scale that ranged from 1 (Strongly Agree) to 6 (Strongly Disagree). All items were reverse-scored with the high end (6) representing high learning-goals (e.g., I like schoolwork in mathematics that I'll learn from, even if I make a lot of mistakes), high performance-approach goals (e.g., I would feel really good if I were the only one who could answer the teachers' questions in my mathematics class), or high performance-avoidance goals (e.g., It's very important to me that I don't look stupid in my mathematics class). In a past study (Midgley et al., 1998), internal consistency ranged from .73 to .81 for learning goals (labeled as task goals), between .62 and .84 for performance-approach goals (labeled as ability-approach goals), and .84 for performance-avoidance goals (labeled as ability-avoid goals). The internal consistency estimates of scores from the present study were .93, .85, and .87 for learning, performance-approach, and performance-avoidance, respectively.

Math-oriented intrinsic motivation. Items to measure intrinsic motivation toward success in mathematics were selected and adapted from the items developed by Lepper et al. (2005). Among three sub-factors (Challenge, Curiosity, and Independent mastery) of the scale, six items designed to measure a sub-factor, Challenge, were used in the present study based on the following reasons. First, when the relationships between motivational constructs (implicit theories of intelligence, achievement goals, and intrinsic motivation) and math achievement were tested, the model including all three sub-factors (Challenge, Curiosity, and Independent mastery) did not provide an acceptable fit index (CFI = .836) although RMSEA was within an acceptable range (RMSEA = .077). Based on the modification indices, I modified the model examining the relationships between motivational constructs (implicit theories of intelligence, achievement goals, and intrinsic motivation) and math achievement. However, the structural equation modeling to test the modified model with all three sub-factors (Challenge, Curiosity, and Independent mastery) was not conducted due to a non-positive definite first-order derivative product matrix. This error might result from the small sample size. Accordingly, it was more proper to include a smaller number of items in the model.

In the present study, I intended to examine how intrinsic motivation mediates the relationship between learning goals and academic achievement and between learning goals and interest in STEM careers. According to the motivation model of implicit theories of intelligence (Dweck & Leggett, 1988; Yeager & Dweck, 2012), learning goals lead students to choose challenging tasks which guide them to successfully achieve in challenging and difficult academic situations. Since a learning goal orientation is a motivational construct related to a mastery-oriented behavior pattern (e.g., a preference of accepting challenges), the focus more on intrinsic motivation regarding a preference of challenges was more proper than other two sub-factors, Curiosity and Independent mastery.

Students rated their beliefs for each item on a 5-point Likert type scale that ranged from 1 (Not at all true) to 5 (Very true for me) (e.g., I like hard work in mathematics because it’s a challenge; I like difficult work in mathematics because I find it more interesting). All items were scored with the high end (5) representing high intrinsic motivation. The internal consistency of the original scales' intrinsic motivation items was .90, and the test-retest reliability was .74 (Lepper et al., 2005). The internal consistency of the scores from the present study was .92 for Challenge in intrinsic motivation.

STEM career interest. STEM career interest was measured by the Career Interest Questionnaire (CIQ; Tyler-Wood, Knezek, & Christensen, 2010). This instrument consists of 12 items on three scales measuring these constructs: perception of supportive environment for pursuing a career in science (e.g., My family is interested in the science courses I take), interest in pursuing educational opportunities that would lead to a career in science (e.g., I would like to have a career in science), and perceived importance of a career in science (e.g., I will have a successful professional career and make substantial scientific contributions). Students rated their agreement or disagreement for each item on a 5-point Likert type scale that ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). All items were scored with the high end (5) representing high interest in STEM careers. Internal consistency reliabilities for the three subscales ranged from .78 to .94, and construct and criterion-related validity of scores from middle school students supported the use of the scale (Tyler-Wood et al., 2010). More specifically, results of construct validity evidence using exploratory factor analysis provided evidence reconfirming the hypothesized constructs, and criterion-related validity evidence using correlations between learner disposition measures and a total score of STEM career interest scale was sound (.53 for Creative Tendencies; .54 for Computer Importance for schooling and career; .42 for Motivation; .42 for Attitudes Toward School).

The internal consistency of scores from the present study ranged from .71 to .92, and the internal consistency of the composite score of the scale was .91.

Academic achievement. The participants' self-reported mathematics course grades were collected to assess academic performance because mathematics achievement is one of the critical factors related to STEM career interest. Students were asked to report their grades in mathematics courses that they had taken in the first, second, and third quarters of the 2015-2016 school year; grades from the third quarter were used for data analysis.[1)] Mathematics courses which students reported were varied. Most of the 9th graders reported enrollment in Algebra 2 or Pre-calculus; 10th graders were primarily enrolled in pre-calculus or AP Calculus BC; AP Calculus AB and BC were most frequently reported by 11th graders; 12th graders mostly reported AP Statistics, Linear Algebra, or AP Calculus AB/BC. Grades were on a 4-point scale, with 4 being the highest grade. High achieving students are considered to be accurate self-reporters of grades, and self-reported grades generally are regarded as a predictor of outcomes to a similar extent as actual grades (Kuncel, Credé & Thomas, 2005).

Data Analysis

I calculated descriptive statistics for the measures of implicit theories of math intelligence, math-oriented goal orientations, math-oriented intrinsic motivation, and STEM career interest of the sample, and I calculated correlations for all of the measures. I then applied structural equation modeling based on the hypothesized model in Figure 2 using full information maximum likelihood estimate to handle any missing data because missing data are missing at random.

1) All grades from the 2015-2016 academic year were collected to see if I can examine a growth model, but since the sample size was small, I did not examine a growth model and chose grades from only one time point which is the third quarter when students' implicit theories of intelligence were assessed.

Before conducting structural equation modeling, I examined univariate and multivariate outliers, as well as multivariate normality to check assumptions. In order to determine the model with the best fit, approximate fit indices including comparative fit index (CFI) and root mean square error of approximation (RMSEA) were examined. The criteria for acceptable model fit should be greater than .90 for CFI and less than .08 for RMSEA (Bentler, 1990; Browne & Cudeck, 1993; Hu & Bentler, 1999). The hypothesized model includes the variables of: Implicit Theories of Intelligence including an Incremental Theory of Intelligence (IT) and an Entity Theory of Intelligence (ET), Math-oriented Achievement Goals consisting of Learning goals (LG), Performance-Approach goals (PAPPG), and Performance-Avoidance goals (PAVG), Math-oriented Intrinsic Motivation (IMOT), mathematics achievement scores (Math), and interest in STEM careers (ISC).

Figure 2. Hypothesized model

Results

Descriptive Statistics

Descriptive statistics and inter-correlations between variables were calculated (Table 1). On average, participants had an incremental theory of intelligence (Mean = 3.90, S.E. = .094), learning goals (Mean = 4.383, S.E. = .098), intrinsic motivation (Mean = 3.381, S.E. = .089), and high interest in STEM careers (Mean = 4.082, S.E. = .054). The results indicated that mathematics achievement was positively correlated with learning goals ($r = .384$, $p < .001$), intrinsic motivation ($r = .438$, $p < .001$) and interest in STEM careers ($r = .194$, $p < .05$), but was negatively correlated with performance-avoidance goals ($r = -.323$, $p < .001$). The negative correlation between mathematics achievement and performance-approach goals ($r = -.074$, $p = 0.207$) was not statistically significant. Interest in STEM careers was positively correlated with learning goals ($r = .343$, $p < .001$), intrinsic motivation ($r = .363$, $p < .001$) and mathematics achievement. The implicit theories of intelligence were not significantly correlated with math achievement or with interest in STEM careers.

Table 1. Means, standard errors, and inter-correlations between measures

Relationships among Implicit Theories of Intelligence, Goals, Intrinsic Motivation and Math Achievement

The hypothesized model (Figure 2) was modified based on the followings steps. First, I considered a second-order factor model that included the second order factor as Implicit Theories of Intelligence (ITI) to account for the high correlation between incremental theory and entity theory factors. Since there was a high correlation ($r = -.823$) between the two constructs, I re-specified the model by collapsing the dimensions into a single factor. However, the single factor model (unidimensional model) provided an unacceptable fit index (RMSEA =.082, CFI = .867). As another re-specification, Brown (2006) suggested a 2^{nd} order factor model to account for the high correlation. The 2^{nd} order factor model was tested because it is consistent with the literature of the implicit theories of intelligence. Second, the model was re-specified by separating three goal orientations into three separate models. When the relationships between motivational constructs (implicit theories of intelligence, achievement goals, and intrinsic motivation) and math achievement were tested, the 2^{nd} order factor model including all three goal orientations provided acceptable fit indices (RMSEA = .072, CFI = .901) with residual correlations on the measurement models of performance-approach and performance-avoidance goal orientations. However, when I tested the 2nd order factor model including all motivational constructs, math achievement and interest in STEM careers, the structural equation modeling was not conducted due to a non-positive definite first-order derivative product matrix. This error may be caused by the small number of participants in the sample. Thus, three goal orientations were tested respectively by creating three models based on separating the three achievement goal orientations – using one in each 2nd order factor model (Models 1, 2, & 3).

The mediational pathways of achievement with standardized path coefficients are shown in Figures 3, 4, and 5. An observed variable measuring a specific latent variable was loaded on its respective latent variable. Implicit Theories of Intelligence were considered to be an exogenous variable. Learning, performance-approach and performance-avoidance goals and intrinsic motivation were considered to be both exogenous and endogenous variables. Mathematics achievement was considered to be an endogenous variable. Models 1, 2, and 3 fit the data well (Model1: $\chi^2_{149} = 253.906$ (p < .001); Model2: $\chi^2_{149} = 270.586$ (p< .001); Model 3: $\chi^2_{132} = 236.894$ (p<.001)) and showed either good or acceptable fit indices (Model 1: CFI = .950, RMSEA = .07; Model 2: CFI = .931, RMSEA = .076; Model 3: CFI = .936, RMSEA = .075). All proposed paths were statistically significant (p< .05) in Model 1. However, the three proposed paths from Implicit Theories of Intelligence to performance-approach goals and from performance-approach goals to intrinsic motivation in Model 2 and from Implicit

Theories of Intelligence to performance-avoidance goals in Model 3 were not statistically significant.

Based on the results of Model 1, Implicit Theories of Intelligence had an indirect positive relationship with mathematics achievement, via learning goals and intrinsic motivation. Implicit Theories of Intelligence positively predicted learning goals (unstandardized regression coefficient = 0.132, $p < .05$), which positively predicted intrinsic motivation (unstandardized regression coefficient = 1.235, $p < .001$), and intrinsic motivation positively predicted math achievement (unstandardized regression coefficient = 0.260, $p < .001$). This means that students with an incremental theory of math intelligence tended to pursue high math-oriented learning goals which led to high math-oriented intrinsic motivation. The higher the math-oriented intrinsic motivation of the students, the better their reported math achievement (grades). As a result, students with an incremental theory of math intelligence were more likely to report high math achievement (grades) than students with an entity theory. The results are shown in Tables 2 and 5.

In Model 2, as shown in Tables 3 and 5, the results indicated that Implicit Theories of Intelligence did not have a significantly positive relation with performance-approach goals, (unstandardized regression coefficient = 0.034, $p = 0.651$) which were not significantly related to intrinsic motivation (unstandardized regression coefficient = -0.110, $p = 0.459$). In Model 3, Implicit Theories of Intelligence were not associated with performance-avoidance goals (unstandardized regression coefficient = 0.024, $p = 0.713$). However, performance-avoidance goals had a significantly negative relationship with intrinsic motivation (unstandardized regression coefficient = -0.539, $p < .05$), and intrinsic motivation was positively associated with math achievement (unstandardized regression coefficient = 0.251, $p < .001$). In other words, performance-avoidance goals indirectly had a negative relationship with math achievement via intrinsic motivation (unstandardized regression coefficient = -0.135, $p < .05$, $d = -0.139$), although Implicit Theories of Intelligence did not indirectly predict math achievement. The results are summarized in Tables 4 and 5.

Table 2. Parameter estimates of factor loadings and residuals for Model 1

Table 3. Parameter estimates of factor loadings and residuals for Model 2

Table 4. Parameter estimates of factor loadings and residuals for Model 3

Figure 3. Model 1: Associations among implicit theories of intelligence, learning goals, intrinsic motivation, and math achievement

Figure 4. Model 2: Associations among implicit theories of intelligence, performance-approach goals, intrinsic motivation, and math achievement

Figure 5. Model 3: Associations among implicit theories of intelligence, performance-avoidance goals, intrinsic motivation, and math achievement

Table 5. Parameter estimates of structural regression factor variances for Models 1, 2, and 3

Relationships among Implicit Theories of Intelligence, Goals, Intrinsic Motivation, Math Achievement, and Interest in STEM Careers

The mediational pathways of STEM career interest with standardized path coefficients are shown in Figure 6. Implicit Theories of Intelligence were considered to be an exogenous variable. Learning, performance-approach, performance-avoidance goals, intrinsic motivation, and mathematics achievement were considered to be both exogenous and endogenous variables. Interest in STEM careers was considered to be an endogenous variable. Model 4 was presented in Figure 6 ($\chi^2_{459} = 743.122$ (p < .001)), and fit indices for Model 4 showed good or acceptable fit (CFI = .906; RMSEA = .066 with 90% confidence interval of [.057, .074]). However, Model 5 to test the relationships among Implicit Theories of Intelligence, performance-approach goals, intrinsic motivation, math achievement and interest in STEM careers did not show a good fit index although RMSEA was acceptable. Model 6 to test the associations among Implicit Theories of Intelligence, performance-avoidance goals, intrinsic motivation, math achievement and interest in STEM careers did not show a good fit index either. (Model 5: $\chi^2_{429} = 743.867$ (p< .001), CFI = .878 , RMSEA = .072 with 90% confidence interval of [0.063, 0.080]; Model 6: $\chi^2_{459} = 780.911$ (p< .001), CFI = .881, RMSEA = .070 with 90% confidence interval of [0.062, 0.078]). Thus, Model 4 was selected as a final model to test the factors associated with interest in STEM careers.

Based on the results of Model 4, Implicit Theories of Intelligence indirectly had a positive relationship with interest in STEM careers, via learning goals and intrinsic motivation. Implicit Theories of Intelligence had a significant positive relationship with learning goals (unstandardized regression coefficient = 0.132, p< .05) and were also indirectly related to intrinsic motivation, via learning goals (unstandardized regression coefficient = 0.163, $p < .05$. $d = 0.160$). In addition, learning goals positively predicted intrinsic motivation (unstandardized regression coefficient = 1.236, $p < .001$) through which learning goals were indirectly associated with interest in STEM careers (unstandardized regression coefficient = 0.297, $p < .05$. $d=0.297$). Intrinsic motivation was significantly associated with interest in STEM careers (unstandardized regression coefficient = 0.241, $p < .001$) and math achievement (unstandardized regression coefficient = 0.258, $p < .001$), although math achievement was not significantly related to interest in STEM careers (unstandardized regression coefficient = 0.118, $p=0.285$). In other words, students with an incremental theory were more likely to pursue learning goals leading to intrinsic motivation, which led students to have higher interest in STEM careers than students with an entity theory. However, the indirect effect of an incremental theory on interest in STEM careers via learning goals and intrinsic motivation was not statistically significant (unstandardized regression coefficient = 0.039, $p=.083$, $d= 0.058$). The results are summarized in Tables 6 and 8.

Table 6. Parameter estimates of factor loadings and residuals for Model 4 and Model 5 with gender

Figure 6. Model 4: Associations among implicit theories of intelligence, performance-avoidance goals, intrinsic motivation, math achievement and interest in STEM careers

Differences by Gender

Multi-group analysis was conducted to compare the final model outlined in Figure 6 by gender. The model fit the data well ($\chi^2_{486} = 785.604$ ($p < .001$), RMSEA= .066 with 90% confidence interval of [.057, .074], CFI= .901). The motivational constructs (Implicit Theories of Intelligence, goal orientations, and intrinsic motivation), mathematics achievement, and interest in STEM careers did not significantly differ between females and males. The results are shown in Tables 6 and 8.

Differences by Age (Grade)

To examine the effect of the covariate of age on Implicit Theories of Intelligence, learning goals, intrinsic motivation and interest in STEM careers, I fit the model with the covariate. The model fit the data well ($\chi^2_{486} = 784.137$ ($p < .001$), RMSEA= .065 with a 90% confidence interval of [.057, .074], CFI= .902). Age measured by grade was significantly and directly related to interest in STEM careers (unstandardized regression coefficient = .117, $p < .05$). This indicates that a one-grade increase on the grade variable predicts a 0.117-point increase on interest in STEM careers. However, age measured by grade did not have a direct relationship with Implicit Theories of Intelligence, learning goals, intrinsic motivation and mathematics achievement. The results are summarized in Tables 7 and 8.

Table 7. Parameter estimates of factor loadings and residuals for Model 6 with age

Table 8. Parameter estimates of structural regression, factor variances for Model 4 and Model 5 with gender and Model 6 with age

Discussion

The purpose of the present study was to examine if the relationship between implicit theories of intelligence and achievement goals impacts learning motivation, academic achievement and interest in STEM careers among academically gifted high school students with talents in science and mathematics, and then to compare the results across gender and age. For this examination, the three research questions identified in the introduction guided the analyses of the present study. First question was: “What are the relationships among the implicit theories of math intelligence, math-oriented achievement goal orientations, math-oriented intrinsic motivation, and math achievement in gifted students attending STEM high schools?” Second question was: “Taking into account the relationships described in Question 1, how are factors that are used to explain motivation (the implicit theories of math intelligence, math-oriented achievement goal orientations, and math-oriented intrinsic motivation) and gifted students’ math achievement associated with STEM career interest? Third question was: “How do the relationships described in Question 1 and 2 vary across gender and age from 9th to 12th grade?”

The findings related to first research question were consistent with those presented in past studies (Blackwell et al., 2007; Chen & Pajares, 2010; Haimovits et al., 2011; Jones et al, 2012; Romero, Master, Paunesku, Dweck, & Gross, 2014; Diseth, Meland & Breidablik, 2014). An incremental theory relative to mathematics was positively related to learning goals; learning goals had a positive relationship with intrinsic motivation. Intrinsic motivation was directly and positively related to math achievement, in line with previous literature demonstrating that intrinsic motivation is positively associated with academic performance in accord with prior research (A. E.

Gottfried, Marcoulides, Gottfried, Oliver, & Guerin, 2007; Lepper, Corpus & Iyengar, 2005). In addition, as demonstrated in past studies (e.g., Harackiewicz, Barron, Tauer, Cater, & Elliot, 2000), performance avoidance goals were significantly and negatively related to intrinsic motivation while performance-approach goals were not significantly associated with intrinsic motivation. That is, among those academically gifted students, an incremental theory was indirectly and positively related to academic performance, through learning goals and intrinsic motivation as shown in other studies (Blackwell et al., 2007; Chen & Pajares, 2010; Haimovits et al., 2011; Jones et al, 2012). In other words, academically gifted students with an incremental theory related to mathematics were more likely to pursue learning goals leading to intrinsic motivation and thus earn higher grades in mathematics than academically gifted students with an entity theory. On the other hand, academically gifted students pursuing performance-avoidance goals tended to have low intrinsic motivation which resulted in low math achievement.

In the second research question, I examined whether an incremental theory of intelligence was related to interest in STEM careers. The analysis of the data suggests that an incremental theory in mathematics is, indeed, related to an interest in STEM careers. In other words, the higher the scores of the academically gifted students on a measure of incremental theory related to mathematics, the higher their scores on a measure of intrinsic motivation which is related to high interest in STEM careers. More specifically, a belief in incremental theory relative to mathematics led students to pursue learning goals, and the learning goals were related to high intrinsic motivation, which was related to high interest in STEM careers. Intrinsic motivation plays a significant role in expressed interest in STEM careers (Christensen et al, 2015). Although researchers have mentioned the importance of math achievement as a predictor of interest in STEM careers (Wang, 2013b; Sadler et al., 2012), the findings of the present study did not support the relationship between math achievement and interest in STEM careers.

In the last research question, I asked if the results demonstrated in the first and second research questions varied across gender and age measured by grade level. Among academically gifted students with talents in science and mathematics, differences in interest in STEM careers did not exist across gender; there was no gender difference in implicit theories of intelligence as researchers reported in prior studies (Dai & Feldhusen, 1996; Hong & Aqui, 2004; Park et al., in press). Although females tended to report lower interest in STEM careers than males in previous studies (e.g., Bailyn, 2003; Blickenstaff, 2005; Kulis & Sicotte, 2002; National Science Foundation, 2011), there was no gender difference on interest in STEM careers among academically gifted students with talents in science and mathematics. These findings are not surprising given the participants in the present study are academically gifted students attending a specialized high school for gifted students with talent in science and mathematics.

Age measured by grade level did not appear to play a significant role in gifted students' implicit theories of intelligence, learning goals and intrinsic motivation. There was no difference in an incremental theory of intelligence across age (measured by grade level) and no difference in learning goals across age. Also, inconsistent with previous works indicating a general decline in academic intrinsic motivation across age (e.g., A. E. Gottfried, Fleming, & Gottfried, 2001; A. W. Gottfried et al., 2005) as the older gifted students in the present study did not exhibit significantly lower intrinsic motivation. Interestingly, older students tended to have higher interest in STEM careers than younger students. These findings may be an indicator of the positive effects of the programming in the school.

Implications

The findings from this study indicate that an incremental theory of intelligence is indirectly and positively related to intrinsic motivation and academic performance through learning goals (Aronson, Fried & Good, 2002; Cury, Elliot, Da Fonseca & Moller, 2006; Haimovitz et al., 2011). These findings suggest that parents and teachers should encourage their children or students to believe their intelligence can be developed and changed through learning and effort. That is, it is important for parents and teachers to emphasize the process of learning, the importance of effort in learning, and a positive attitude toward engaging in challenge.

In addition, intrinsic motivation was a critical factor directly associated with interest in STEM careers, and mathematics performance did not play a significant role in maintaining interest in STEM careers. These findings suggest that parents and educators should encourage the development of intrinsic motivation in children and adolescents by emphasizing enjoyment and interest as a consequence of engagement and success.

Limitations

Despite the encouraging findings, there were some limitations in this study. First, even though an online survey was convenient and was used to avoid disruption of the school instructional schedule, this resulted in a relatively small sample size for the analysis I used. The administration use of a traditional paper and pencil survey during school hours may have increased the sample. Although there was a study (Jones et al., 2012) using a structural equation modeling with 163 participants to investigate the relationship among implicit theories of intelligence, other motivational variables and academic performance, a larger sample size would be necessary to make findings of the current study more statistically sound. Also, the results of the study reflect data from self-report measures. Several researchers (Duckworth & Yeager, 2015; Eid & Diener, 2006) have suggested a multimethod approach using various measures such as interview, self-report, teacher-report, parent-report questionnaire, or observation increase reliability and validity of the interpretation of outcomes related to the variable. Thus, it would be worthwhile to examine the hypothesized model with a larger sample using a multi-method approach, such as interviews, teacher-reports, parents-reports and/or self- reports with anchoring vignettes, in future research.

Further, the present study is a correlational study; hence one cannot discuss causality of the relationships among variables. In order to determine if an incremental theory of intelligence leads to learning goals, intrinsic motivation, high academic performance and high interest in STEM career, that is, to examine causality, it would be necessary to collect experimental data by providing mindset interventions.

Finally, although I investigated whether there were differences in implicit theories of intelligence, achievement goal orientations, intrinsic motivation, and interest in STEM careers across age, this was a cross-sectional study. A longitudinal study to examine how gifted students' theories of intelligence, learning goals and intrinsic motivation change as they age would add validity to the findings.

Conclusion

The present study extends the literature on implicit theories of intelligence by documenting that an incremental theory of intelligence related to mathematics is associated with students' interest in STEM careers mediated by learning goals and intrinsic motivation. Recent research about implicit theories of intelligence has demonstrated that an incremental theory has a positive impact on school persistence intentions (Renaud-Dubé, Guay, Talbot, Taylor, & Koestner, 2015). The present study emphasized the importance of an incremental theory of intelligence again in that implicit theories of intelligence in mathematics are related to not only academic performance in mathematics but also future STEM career interest through learning goals and intrinsic motivation. Thus, given that an incremental theory of intelligence is crucial to academically gifted students, it would be worthwhile to examine if academically gifted students benefit from mindset interventions, particularly when those academically gifted students are placed in a highly selective school environment competing with equally talented peers.

An additional contribution of the present study is that it investigated implicit theories of intelligence of academically gifted students with talents in science and mathematics. The findings indicated that an incremental theory of intelligence in mathematics is also important for academically gifted students to grow academically and further to maintain intrinsic motivation directly associated with interest in their talent-related careers. In addition, given that participants in the present study were academically gifted students attending STEM high schools with selective admission processes, the current study provides educators at such a specialized environment with information about potential strategies for encouraging gifted students to maintain interest in their talent areas and to develop their potential when gifted students face academic challenges or failure in a highly selective school environment. In future studies, it would be meaningful to investigate how others’ implicit theories of intelligence such as peers or teachers at schools are associated with students’ implicit theories of intelligence and how school environments have an impact on students’ implicit theories of intelligence.

Lastly, I explored whether the relationship between an incremental theory and learning goals has a positive impact on intrinsic motivation because intrinsic motivation is considered to be critical to maintain interest in STEM careers (Christensen et al, 2015). The findings of the present study showed the indirect and positive relationship between an incremental theory and intrinsic motivation through learning goals. On a related note, in research about creativity, intrinsic motivation is considered to be a very important factor for reaching creative achievement (Amabile, 1983, Csíkszentmihályi, 1988; Olszewski-Kubilius, Subotnik & Worrell, 2015), and certain characteristics of individuals with an incremental theory of intelligence, for example, preference for challenging tasks and extended efforts to tackle challenging tasks, are similar to personalities of creative individuals. Therefore, in future research, it would be meaningful to examine if implicit theories of intelligence are associated with creative personality in the STEM fields.

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Appendix A. Implicit Theories of Math Intelligence Scale

Read each sentence below and then circle the *one* number that shows how much you agree with it.

1. You have a certain amount of mathematics intelligence, and you can't really do much to change it.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

2. Your mathematics intelligence is something about you that you can't change very much.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

3. No matter who you are, you can significantly change your mathematics intelligence level.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

4. You can always substantially change how intelligent you are in a domain of mathematics.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

5. You can learn new things, but you can't really change your mathematics intelligence.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

6. No matter how much mathematics intelligence you have, you can always change it quite bit.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

Appendix B. Achievement Goal Orientation Scale

Circle the answer that best fits your beliefs.

1. I like schoolwork in mathematics that I'll learn from, even if I make a lot of mistakes.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

2. I would feel really good if I were the only one who could answer the teachers' questions in my mathematics class.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

3. It's very important to me that I don't look stupid in my mathematics class.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

4. An important reason why I do my schoolwork in mathematics is because I like to learn new things about mathematics.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

5. I like schoolwork in mathematics best when it really makes me think.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

6. I'd like to show my teachers that I'm smarter than the other students in my mathematics class.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

7. The reason I do my mathematics work is so others won't think I'm dumb.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

8. An important reason I do my mathematics work is so that I don't embarrass myself.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

9. I would feel successful in my mathematics class if I did better than most of the other students.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

10. Doing better than other students in my mathematics class is important to me.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

11. An important reason why I do my work in mathematics is because I want to get better at it.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

12. I do my schoolwork in mathematics because I'm interested in it.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

13. One of my main goals is to avoid looking like I can't do my mathematics work.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

14. I want to do better than other students in my mathematics class.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

15. One reason I would not participate in my mathematics class is to avoid looking stupid.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

16. The reason I do my schoolwork in mathematics is so my teachers don't think I know less than others.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

17. An important reason I do my schoolwork in mathematics is because I enjoy it.

1	2	3	4	5	6
Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree

Appendix C. Intrinsic Motivation Scale

Circle the answer that best fits your beliefs.

1. I like difficult work in mathematics because I find it more interesting.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

2. I like to go on to new work in mathematics that is at a more difficult level.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

3. I read things about mathematics because I am interested in the subject of mathematics.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

4. I work on mathematics problems to learn how to solve them.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

5. When I make a mistake in mathematics problems I like to figure out the right answer by myself.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

6. I like to do my schoolwork in mathematics without help.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

7. I like hard work in mathematics because it's a challenge.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

8. I like difficult problems in mathematics because I enjoy trying to figure them out.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

9. I do my schoolwork in mathematics to find out about a lot of things I've been wanting to know.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

10. When I don't understand something about mathematics right away I like to try to figure it out by myself.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

11. If I get stuck on a mathematics problem, I keep trying to figure out the problem on my own.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

12. I like to learn as much as I can in my mathematics class.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

13. I do extra mathematics projects because I can learn about things that interest me.

1	2	3	4	5

Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

14. I like to try to figure out how to do mathematics assignments on my own.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

15. I like a mathematics subject that makes me think pretty hard and figure things out.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

16. I work really hard because I really like to learn new things about mathematics.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

17. I ask questions in my mathematics class because I want to learn new things.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

18. I don’t like to figure out difficult problems in mathematics.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

19. I work on mathematics problems because I’m supposed to.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

20. I like the teacher to help me plan what to do next when I work on a mathematics problem.

1	2	3	4	5

Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

21. I like to stick to the assignments in mathematics which are pretty easy to do.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

22. I read things related to mathematics because the teacher wants me to.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

23. When I make a mistake in mathematics, I like to ask the teacher how to get the right answer.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

24. I don't like difficult schoolwork in mathematics because I have to work too hard.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

25. I do my schoolwork in mathematics because teacher tells me to.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

26. I like to ask the teacher how school assignments in mathematics should be done.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

27. I like easy work in mathematics that I am sure I can do.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

28. I like to have the teacher help me with my schoolwork in mathematics.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

29. I like mathematics where it's pretty easy to just learn the answers.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

30. If I get stuck on a mathematics problem, I ask the teacher for help.

1	2	3	4	5
Not at all true	Slightly true for me	Somewhat true for me	True for me	Very true for me

Appendix D. STEM Career Interest Scale

Circle the answer that best fits your beliefs.

1. I would like to have a career in science.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

2. My family is interested in the science courses I take.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

3. I would enjoy a career in science.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

4. My family has encouraged me to study science.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

5. I will make it into a good college and major in an area needed for a career in science.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

6. I will graduate with a college degree in a major area needed for a career in science.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

7. I will have a successful professional career and make substantial scientific contributions.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

8. I will get a job in a science-related area.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

9. Some day when I tell others about my career, they will respect me for doing scientific work.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

10. A career in science would enable me to work with others in meaningful ways.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

11. Scientists make a meaningful difference in the world.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

12. Having a career in science would be challenging.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

13. I would like to work with people who make discoveries in science.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

Table 1. Means, standard errors, and inter-correlations between measures

	ITI	LG	PAPPG	PAVG	IMOT	ISC	Math	Grade
ITI	1							
LG	.184*	1						
PAPPG	.031	.010	1					
PAVG	.027	-.212*	.550**	1				
IMOT	.114	.849**	-.026	-.320**	1			
ISC	.076	.343**	.224*	.040	.363**	1		
Math	.144	.384**	-.074	-.323**	.438**	.194*	1	
Grade	-.006	-.061	-.054	.037	-.132	.089	-.070	1
Mean	3.90	4.383	3.830	2.847	3.381	4.082	3.426	.
S.E.	.094	.098	.090	.088	.089	.054	.055	.

Note. ITI = Incremental theory with high scores and Entity theory with low scores, LG = Learning goals, PAPPG = Performance-approach goals, PAVG = Performance-avoidance goals, IMOT = Intrinsic motivation, ISC= Interest in STEM careers, Math = Math achievement; 6-point rating scale = GM, LG, PAPPG, PAVG; 5-point rating scale = IMOT, Interest in STEM; Math = 4-point rating scale; Grade = 9th~12th grades; ** $p<.001$, * $p< .05$

Table 2.

Parameter estimates of factor loadings and residuals for the Model1 of the implicit theories of intelligence, learning goal orientation, intrinsic motivation, and math achievement

	Factor loadings			Measurement errors		
Indicator	Unstandardized	Standard error	Standardized	Unstandardized	Standard error	Standardized
Implicit Theories of Intelligence (ITI)						
Entity by						
ET1	1.000	0.000	0.930	0.207	0.045	0.135
ET2	1.063	0.058	0.923	0.261.	0.052	0.149
ET5	0.894	0.071	0.810	0.554	0.082	0.344
Incremental by						
IT3	1.000	0.000	0.954	0.142	0.051	0.091
IT4	0.856	0.060	0.843	0.425	0.065	0.290
IT6	0.706	0.052	0.832	0.314	0.049	0.307
ITI by						
Entity	1.000	0.000	0.923	0.197	0.105	0.149
Incremental	1.000	0.000	0.892	0.291	0.110	0.205
Learning goal orientation (LG)						
LG by						
LG1	1.000	0.000	0.677	0.608	0.080	0.542
LG2	1.791	0.191	0.925	0.277	0.048	0.144
LG3	1.510	0.174	0.839	0.491	0.071	0.296
LG4	0.855	0.133	0.609	0.636	0.083	0.629
LG5	1.753	0.186	0.938	0.217	0.041	0.121
LG6	1.777	0.193	0.904	0.364	0.058	0.183
Intrinsic motivation (IMOT)						
IMOT by						
IMOT1	1.000	0.000	0.904	0.261	0.044	0.182
IMOT2	1.006	0.066	0.889	0.316	0.051	0.210
IMOT3	0.988	0.065	0.888	0.307	0.049	0.211
IMOT4	1.054	0.068	0.899	0.308	0.051	0.191
IMOT5	1.454	0.085	0.458	0.913	0.121	0.790
IMOT6	0.897	0.067	0.848	0.369	0.056	0.281

Note. ITI= Implicit Theories of Intelligence; ET = Entity theory of intelligence; IT = Incremental theory of intelligence; PAPPG = Performance-approach goal orientation; PAVG = Performance-avoidance goal orientation; LG = Learning goal orientation; IMOT= Intrinsic motivation

Table 3.

Parameter estimates of factor loadings and residuals for the Model2 of the implicit theories of intelligence, performance-approach goal orientation, intrinsic motivation, and math achievement

	Factor loadings			Measurement errors		
Indicator	Unstandardized	Standard error	Standardized	Unstandardized	Standard error	Standardized
Implicit Theories of Intelligence (ITI)						
Entity by						
ET1	1.000	0.000	0.929	0.207	0.045	0.137
ET2	1.067	0.058	0.923	0.260	0.052	0.148
ET5	0.896	0.071	0.809	0.556	0.082	0.346
Incremental by						
IT3	1.000	0.000	0.955	0.138	0.051	0.087
IT4	0.853	0.060	0.843	0.427	0.065	0.289
IT6	0.703	0.052	0.832	0.317	0.049	0.308
ITI by						
Entity	1.000	0.000	0.929	0.179	0.106	0.136
Incremental	1.000	0.000	0.885	0.312	0.113	0.216
Performance-approach goal orientation						
PAPPG by						
PAPPG1	1.000	0.000	0.564	1.232	0.169	0.682
PAPPG2	1.184	0.207	0.663	1.025	0.149	0.561
PAPPG3	1.167	0.193	0.772	0.530	0.086	0.404
PAPPG4	1.386	0.225	0.837	0.471	0.091	0.300
PAPPG5	1.303	0.209	0.830	0.441	0.083	0.312
Intrinsic motivation						
IMOT by						
IMOT1	1.000	0.000	0.912	0.245	0.043	0.169
IMOT2	1.003	0.064	0.893	0.308	0.051	0.202
IMOT3	0.988	0.065	0.891	0.307	0.056	0.207
IMOT4	1.055	0.067	0.903	0.304	0.052	0.185
IMOT5	0.430	0.086	0.438	0.939	0.124	0.808
IMOT6	0.894	0.067	0.848	0.377	0.057	0.281

Note. ITI= Implicit Theories of Intelligence; ET = Entity theory of intelligence; IT = Incremental theory of intelligence; PAPPG = Performance-approach goal orientation; IMOT= Intrinsic motivation

Table 4.

Parameter estimates of factor loadings and residuals for the Model3 of the implicit theories of intelligence, performance-avoidance goal orientation, intrinsic motivation, and math achievement

	Factor loadings			Measurement errors		
Indicator	Unstandardized	Standard error	Standardized	Unstandardized	Standard error	Standardized
Implicit Theories of Intelligence (ITI)						
Entity by						
ET1	1.000	0.000	0.929	0.207	0.045	0.137
ET2	1.068	0.059	0.923	0.259	0.052	0.148
ET5	0.896	0.071	0.809	0.556	0.082	0.346
Incremental by						
IT3	1.000	0.000	0.955	0.138	0.051	0.087
IT4	0.853	0.060	0.843	0.426	0.065	0.289
IT6	0.703	0.052	0.832	0.317	0.049	0.308
ITI by						
Entity	1.000	0.000	0.930	0.176	0.106	0.135
Incremental	1.000	0.000	0.885	0.314	0.113	0.217
Performance-avoidance goal orientation						
PAVG by						
PAVG1	1.000	0.000	0.519	1.227	0.164	0.731
PAVG2	1.205	0.220	0.767	0.459	0.071	0.412
PAVG3	1.618	0.279	0.869	0.382	0.076	0.244
PAVG4	1.700	0.286	0.841	0.540	0.095	0.292
PAVG5	1.340	0.256	0.639	1.179	0.163	0.592
PAVG6	1.340	0.235	0.784	0.508	0.080	0.385
Intrinsic motivation						
IMOT by						
IMOT1	1.000	0.000	0.910	0.251	0.044	0.172
IMOT2	1.004	0.065	0.892	0.312	0.051	0.204
IMOT3	0.991	0.065	0.892	0.304	0.050	0.204
IMOT4	1.059	0.068	0.905	0.301	0.052	0.181
IMOT5	0.435	0.086	0.443	0.935	0.124	0.804
IMOT6	0.897	0.067	0.850	0.374	0.057	0.277

Note. ITI= Implicit Theories of Intelligence; ET = Entity theory of intelligence; IT = Incremental theory of intelligence; PAVG = Performance-avoidance goal orientation; IMOT= Intrinsic motivation

Table 5.

Parameter estimates of structural regression, factor variances for the models of the implicit theories of intelligence, learning goal orientations, intrinsic motivation, and math achievement

Parameters	Unstandardized	Standard error	Standardized
		Model 1	
Structural regression			
LG on ITI	0.132*	0.067	0.196*
IMOT on LG	1.235**	0.157	0.817**
Math on IMOT	0.260**	0.051	0.429**
Factor variances			
LG	0.494**	0.116	0.962**
IMOT	0.390**	0.073	0.333**
Math	0.350**	0.043	0.816**
		Model 2	
Structural regression			
PAPPG on ITI	0.034	0.075	0.048
IMOT on PAPPG	-0.110	0.149	-0.076
Math on IMOT	0.247**	0.051	0.414**
Factor variances			
PAPPG	0.572*	0.179	0.998**
IMOT	1.199**	0.186	0.994**
Math	0.356**	0.044	0.829**
		Model 3	
Structural regression			
PAVG on ITI	0.024	0.066	0.038
IMOT on PAVG	-0.539*	0.180	-0.329**
Math on IMOT	0.251**	0.051	0.422**
Factor variances			
PAVG	0.451	0.154	0.999**
IMOT	1.079	0.171	0.892**
Math	0.353	0.043	0.822**

Note: * for p<.05; ITI = Implicit Theories of Intelligence; ET = Entity theory of intelligence; IT = Incremental theory of intelligence; PAPPG = Performance-approach goal orientation; PAVOIDG = Performance-avoidance goal orientation; LG = Learning goal orientation; IMOT= Intrinsic motivation

Table 6.

Parameter estimates of factor loadings and residuals for the Model 4 and Model5 with gender

Indicator	Factor loadings			Measurement errors		
	Unstandardized	Standard error	Standardized	Unstandardized	Standard error	Standardized
Implicit Theories of Intelligence (ITI)						
Entity by						
ET1	1.000(1.000)	0.000(0.000)	0.930(0.931)	0.207(0.205)	0.045(0.045)	0.135(0.133)
ET2	1.063(1.059)	0.058(0.057)	0.923(0.922)	0.261(0.264)	0.052(0.053)	0.149(0.150)
ET5	0.894(0.891)	0.071(0.070)	0.810(0.811)	0.554(0.553)	0.082(0.082)	0.344(0.342)
Incremental by						
IT3	1.000(1.000)	0.000(0.000)	0.954(0.953)	0.142(0.142)	0.051(0.051)	0.092(0.090)
IT4	0.857(0.858)	0,060(0.060)	0.843(0.842)	0.425(0.426)	0.065(0.065)	0.292(0.290)
IT6	0.706(0.708)	0.052(0.052)	0.832(0.832)	0.314(0.313)	0.049(0.049)	0.308(0.307)
ITI by						
Entity	1.000(1.000)	0.000(0.000)	0.923(0.918)	0.197(0.210)	0.105(0.104)	0.157(0.146)
Incremental	1.000(1.000)	0.000(0.000)	0.892(0.896)	0.291(0.278)	0.110(0.109)	0.198(0.208)
Learning goal orientation (LG)						
LG by						
LG1	1.000(1.000)	0.000(0.000)	0.676(0.677)	0.608(0.608)	0.080(0.080)	0.542(0.542)
LG2	1,792(1.792)	0.191(0.191)	0.925(0.925)	0.277(0.277)	0.048(0.048)	0.144(0.144)
LG3	1.510(1.509)	0.174(0.174)	0.839(0.839)	0.492(0.492)	0.071(0.071)	0.296(0.296)
LG4	0.855(0.855)	0.133(0.133)	0.609(0.609)	0.636(0.636)	0.083(0.083)	0.629(0.629)
LG5	1.754(1.754)	0.186(0.186)	0.938(0.938)	0.217(0.217)	0.041(0.041)	0.121(0.121)
LG6	1.778(1.778)	0.194(0.194)	0.904(0.904)	0.363(0.363)	0.058(0.058)	0.183(0.183)
Intrinsic motivation (IMOT)						
IMOT by						
IMOT1	1.000(1.000)	0.000(0.000)	0.905(0.905)	0.259(0.260)	0.044(0.044)	0.181(0.181)
IMOT2	1.008(1.008)	0.065(0.065)	0.891(0.891)	0.310(0.311)	0.050(0.051)	0.206(0.207)
IMOT3	0.985(0.985)	0.065(0.065)	0.886(0.886)	0.312(0.312)	0.049(0.050)	0.215(0.215)
IMOT4	1.051(1.052)	0.068(0.068)	0.898(0.898)	0.312(0.311)	0.052(0.052)	0.194(0.193)
IMOT5	0.452(0.452)	0.085(0.085)	0.456(0.456)	0.915(0.915)	0.121(0.121)	0.792(0.792)
IMOT6	0.897(0.897)	0.066(0.066)	0.848(0.849)	0.368(0.367)	0.055(0.055)	0.280(0.280)
Interest in STEM careers (ISC)						
ISC by						
ISC1	1.000(1.000)	0.000(0.000)	0.791(0.792)	0.307(0.307)	0.046(0.046)	0.374(0.373)
ISC2	0.657(0.658)	0.122(0.122)	0.491(0.492)	0.699(0.698)	0.094(0.094)	0.759(0.758)
ISC3	0.844(0.844)	0.092(0.092)	0.761(0.762)	0.265(0.265)	0.039(0.039)	0.420(0.419)
ISC4	0.585(0.585)	0.129(0.129)	0.420(0.421)	0.823(0.823)	0.110(0.110)	0.824(0.823)

ISC5	0.962(0.961)	0.096(0.096)	0.829(0.830)	0.216(0.216)	0.034(0.034)	0.312(0.311)
ISC6	1.171(1.170)	0.104(0.104)	0.901(0.902)	0.162(0.162)	0.030(0.030)	0.187(0.187)
ISC7	0.985(0.983)	0.107(0.107)	0.785(0.785)	0.310(0.311)	0.046(0.046)	0.384(0.384)
ISC8	1.082(1.081)	0.106(0.106)	0.843(0.843)	0.245(0.246)	0.038(0.038)	0.290(0.290)
ISC9	0.987(0.986)	0.115(0.115)	0.744(0.744)	0.405(0.405)	0.059(0.059)	0.447(0.447)
ISC10	0.646(0.646)	0.094(0.094)	0.615(0.616)	0.353(0.352)	0.049(0.049)	0.622(0.621)
ISC11	0.253(0.253)	0.065(0.065)	0.369(0.369)	0.210(0.210)	0.028(0.028)	0.864(0.864)
ISC12	0.253(0.252)	0.095(0.095)	0.254(0.254)	0.477(0.477)	0.063(0.063)	0.935(0.935)
ISC13	0.688(0.687)	0.100(0.100)	0.611(0.611)	0.408(0.408)	0.056(0.056)	0.626(0.626)

Note. ITI = Implicit Theories of Intelligence; ET = Entity theory of intelligence; IT = Incremental theory of intelligence; PAPPG = Performance-approach goal orientation; PAVG = Performance-avoidance goal orientation; LG = Learning goal orientation; ISC = Interest in STEM careers; IMOT= Intrinsic motivation; the numbers in the parentheses = parameter estimates for the Model 5

Table 7.

Parameter estimates of factor loadings and residuals for the Model6 with age

	Factor loadings			Measurement errors		
Indicator	Unstandardized	Standard error	Standardized	Unstandardized	Standard error	Standardized
Implicit Theories of Intelligence (ITI)						
Entity by						
ET1	1.000	0.000	0.930	0.207	0.045	0.136
ET2	1.064	0.058	0.923	0.261.	0.052	0.149
ET5	0.894	0.071	0.810	0.554	0.082	0.344
Incremental by						
IT3	1.000	0.000	0.954	0.141	0.051	0.091
IT4	0.856	0.060	0.843	0.426	0.065	0.290
IT6	0.705	0.052	0.832	0.315	0.049	0.307
Mindsets by						
Entity	1.000	0.000	0.923	0.192	0.105	0.149
Incremental	1.000	0.000	0.892	0.296	0.111	0.205
Learning goal orientation (LG)						
LG by						
LG1	1.000	0.000	0.676	0.609	0.080	0.542
LG2	1.792	0.191	0.925	0.278	0.048	0.144
LG3	1.510	0.174	0.839	0.491	0.071	0.296
LG4	0.854	0.133	0.609	0.636	0.083	0.629
LG5	1.755	0.186	0.938	0.217	0.041	0.121
LG6	1.778	0.194	0.904	0.363	0.058	0.183
Intrinsic motivation (IMOT)						
IMOT by						
IMOT1	1.000	0.000	0.906	0.258	0.044	0.180
IMOT2	1.008	0.065	0.892	0.309	0.050	0.205
IMOT3	0.985	0.065	0.887	0.311	0.049	0.214
IMOT4	1.050	0.068	0.898	0.313	0.052	0.194
IMOT5	0.452	0.085	0.456	0.915	0.121	0.792
IMOT6	0.896	0.066	0.848	0.369	0.056	0.281
Interest in STEM careers (ISC)						
ISC by						
ISC1	1.000	0.000	0.791	0.306	0.046	0.375
ISC2	0.656	0.122	0.489	0.700	0.094	0.761
ISC3	0.841	0.092	0.759	0.267	0.039	0.424
ISC4	0.586	0.129	0.420	0.822	0.110	0.824
ISC5	0.963	0.096	0.831	0.213	0.033	0.310

ISC6	1.173	0.104	0.903	0.159	0.030	0.184
ISC7	0.982	0.107	0.783	0.312	0.046	0.387
ISC8	1.081	0.106	0.842	0.246	0.038	0.291
ISC9	0.983	0.115	0.740	0.408	0.059	0.452
ISC10	0.643	0.094	0.612	0.354	0.049	0.626
ISC11	0.252	0.065	0.366	0.210	0.028	0.866
ISC12	0.251	0.095	0.252	0.477	0.063	0.937
ISC13	0.685	0.100	0.608	0.410	0.056	0.631

Note. ITI = Implicit Theories of Intelligence; ET = Entity theory of intelligence; IT = Incremental theory of intelligence; PAPPG = Performance-approach goal orientation; PAVG = Performance-avoidance goal orientation; LG = Learning goal orientation; IMOT = Intrinsic motivation; ISC = Interest in STEM careers

Table 8.

Parameter estimates of structural regression, factor variances for the Model 4, the Model 5 with gender and the Model 6 with age

Parameters	Unstandardized	Standard error	Standardized
		Model 4	
Structural regression			
LG on ITI	0.132*	0.067	0.196*
IMOT on LG	1.236**	0.157	0.817**
Math on IMOT	0.258**	0.051	0.427**
ISC on Math	0.118	0.110	0.107
ISC on IMOT	0.241*	0.070	0.364**
Factor variances			
Learning goals	0.493**	0.116	0.962**
Intrinsic motivation	0.391**	0.073	0.333**
Math	0.350**	0.043	0.818**
Interest in STEM careers	0.423**	0.085	0.823**
		Model 5 with Gender	
Structural regression			
Learning goals on			
Mindsets	0.130	0.068	0.193*
Gender	-0.006	0.131	-0.004
Intrinsic motivation on			
Learning goals	1.233**	0.157	0.816**
Gender	-0.098	0.130	-0.045
Math on			
Intrinsic motivation	0.253**	0.051	0.418**
Gender	-0.194	0.101	-0.147
Interest in STEM Careers on			
Intrinsic motivation	0.241*	0.070	0.364**
Math	0.133	0.113	0.121
Gender	0.094	0.132	0.065
Mindsets on			
Gender	-0.313	0.200	-0.146
Factor variances			
Learning goals	0.494**	0.116	0.962
Intrinsic motivation	0.388**	0.073	9.339
Math	0.341**	0.042	0.795
Interest in STEM Careers	0.422**	0.085	0.817
		Model 6 with Age	
Structural regression			
Learning goals on			

Mindsets	0.132*	0.067	0.196*
Age	-0.039	0.057	-0.061
Intrinsic motivation on			
Learning goals	1.232**	0.157	0.813**
Age	-0.062	0.057	-0.064
Math on			
Intrinsic motivation	0.258**	0.051	0.428**
Age	-0.014	0.046	-0.023
Interest in STEM Careers on			
Intrinsic motivation	0.255**	0.069	0.386**
Math	0.104	0.108	0.096
Age	0.117*	0.056	0.182*
Mindsets on			
Age	0.024	0.089	0.025
Factor variances			
Learning goals	0.492**	0.116	0.958**
Intrinsic motivation	0.388**	0.072	0.329**
Math	0.349**	0.043	0.814**
Interest in STEM Careers	0.407**	0.082	0.795**

Note. ITI = Implicit Theories of Intelligence; LG = Learning goals, IMOT= Intrinsic motivation, Math= Math achievement, ISC = Interest in STEM careers

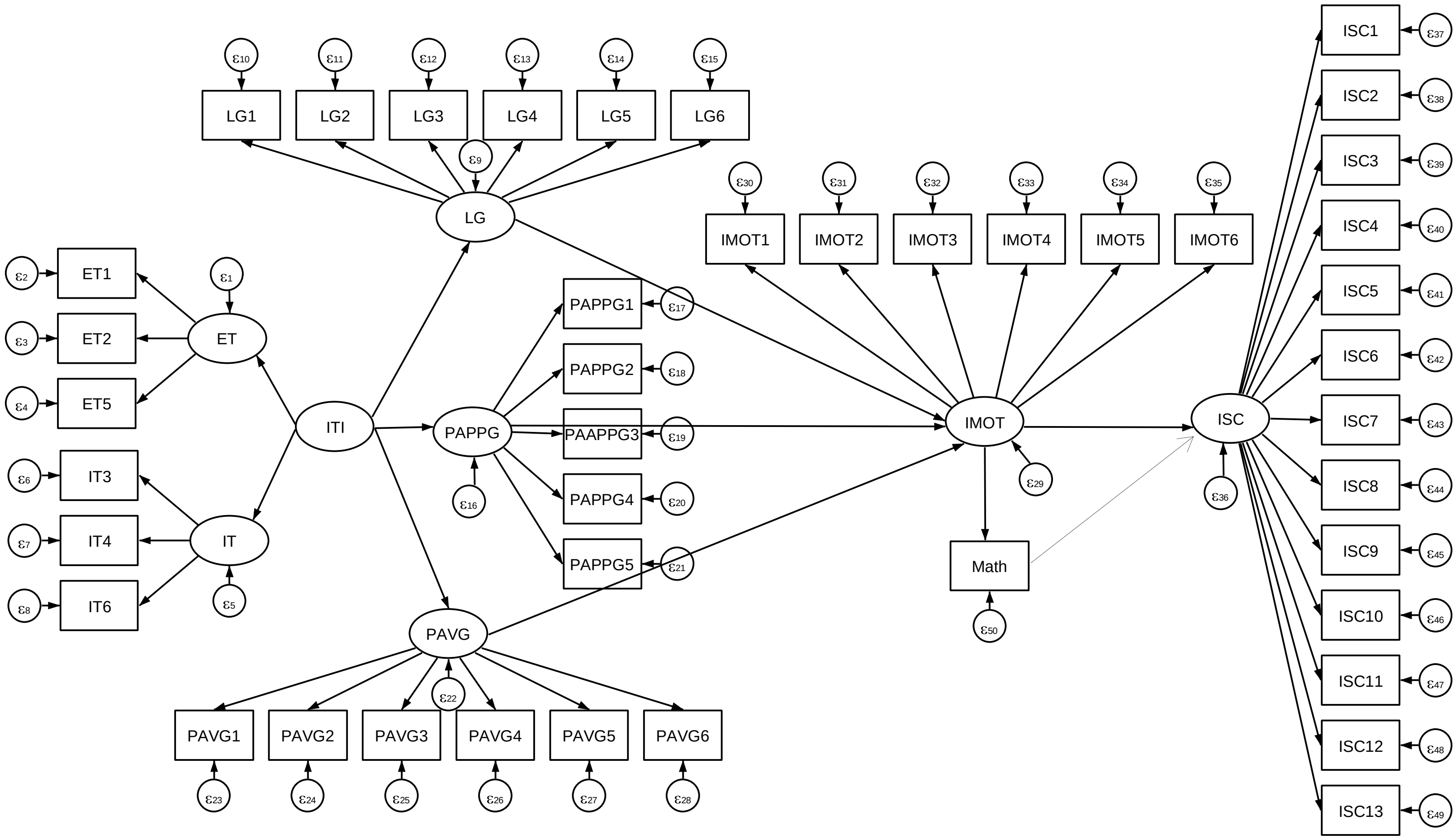

Figure 2. Hypothesized model: Associations among implicit theories of intelligence (ITI), achievement goals (learning (LG), performance-approach (PAPPG), and performance-avoidance (PAVG) goals), intrinsic motivation (IMOT), math achievement (Math) and interest in STEM careers (ISC)

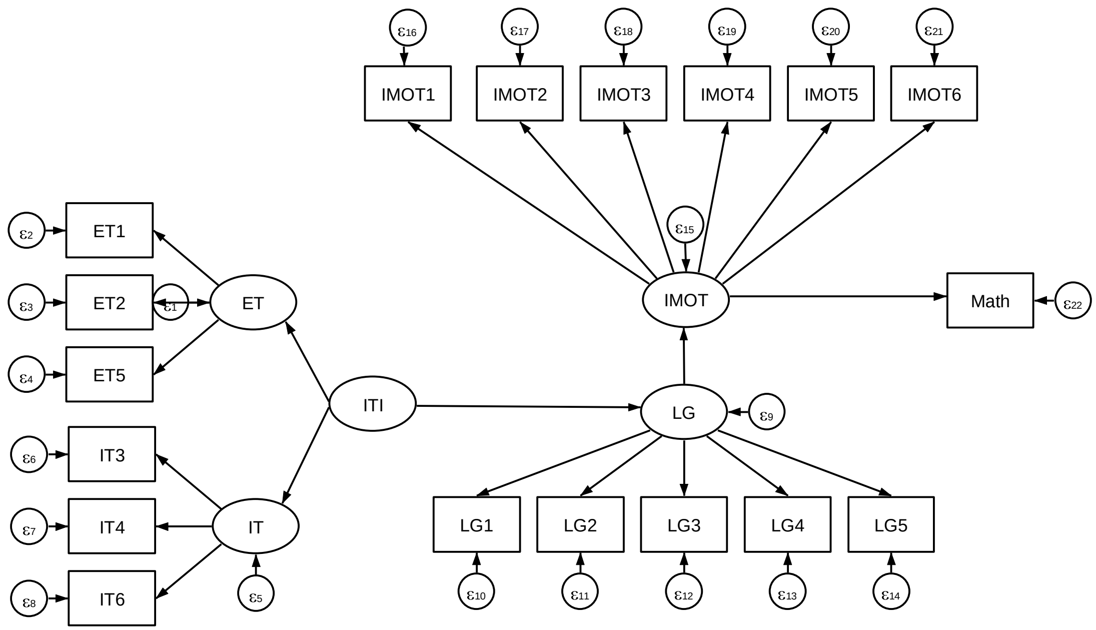

Figure 3. Model1: Associations among implicit theories of intelligence (ITI), learning goals (LG), intrinsic motivation (IMOT), and math achievement (Math)

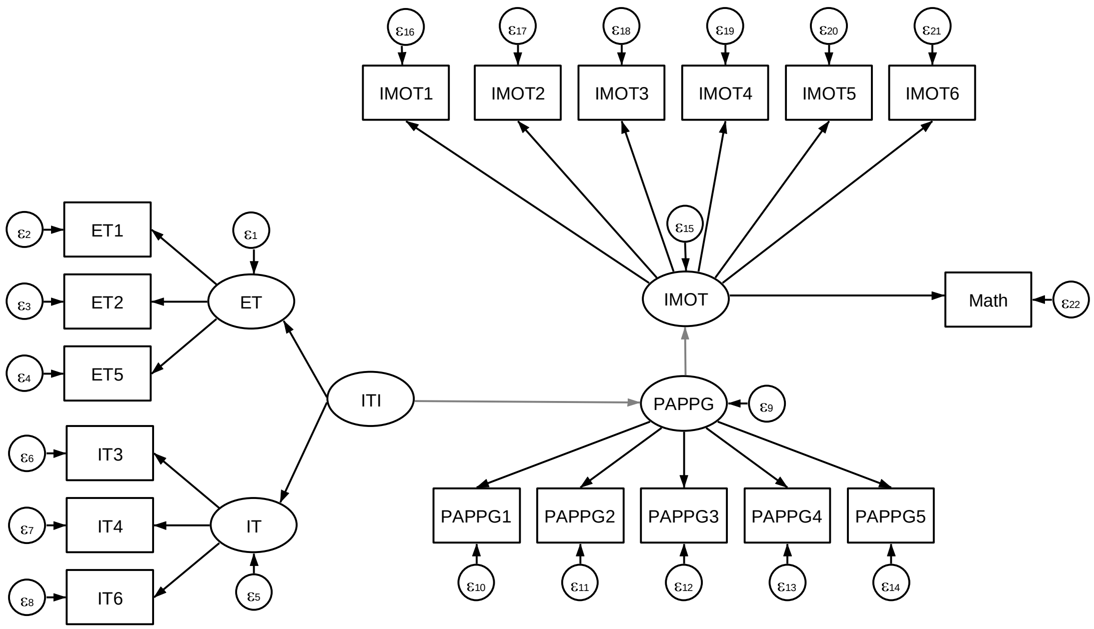

Figure 4. Model 2: Associations among implicit theories of intelligence (ITI), performance-approach goals (PAPPG), intrinsic motivation (IMOT), and math achievement (Math)

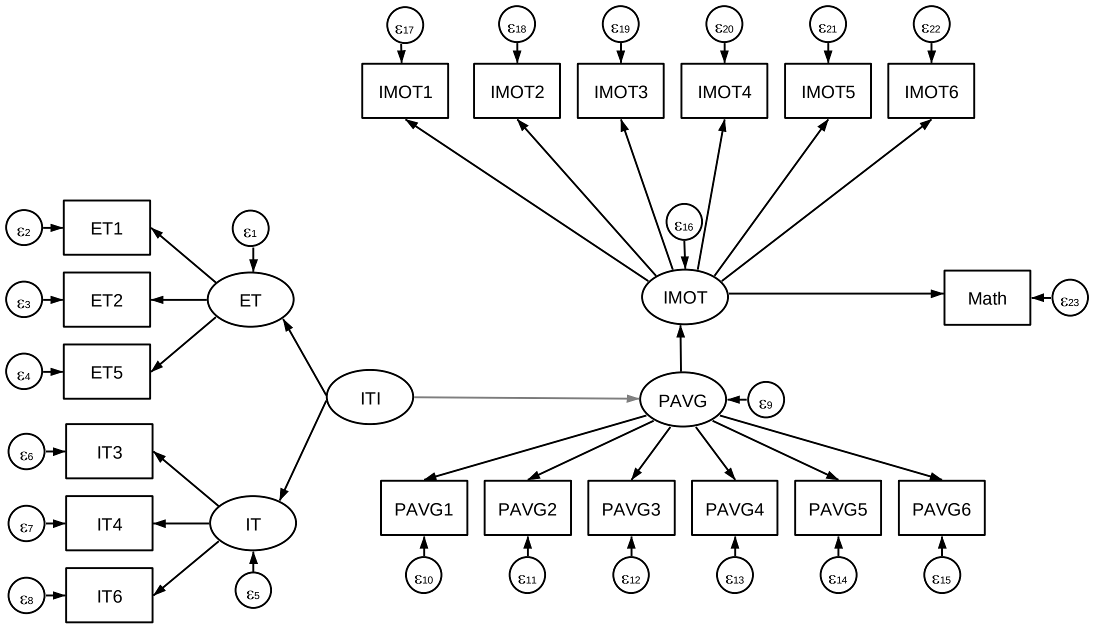

Figure 5. Model 3: Associations among implicit theories of intelligence (ITI), performance-avoidance goals (PAVG), intrinsic motivation (IMOT), and math achievement (Math)

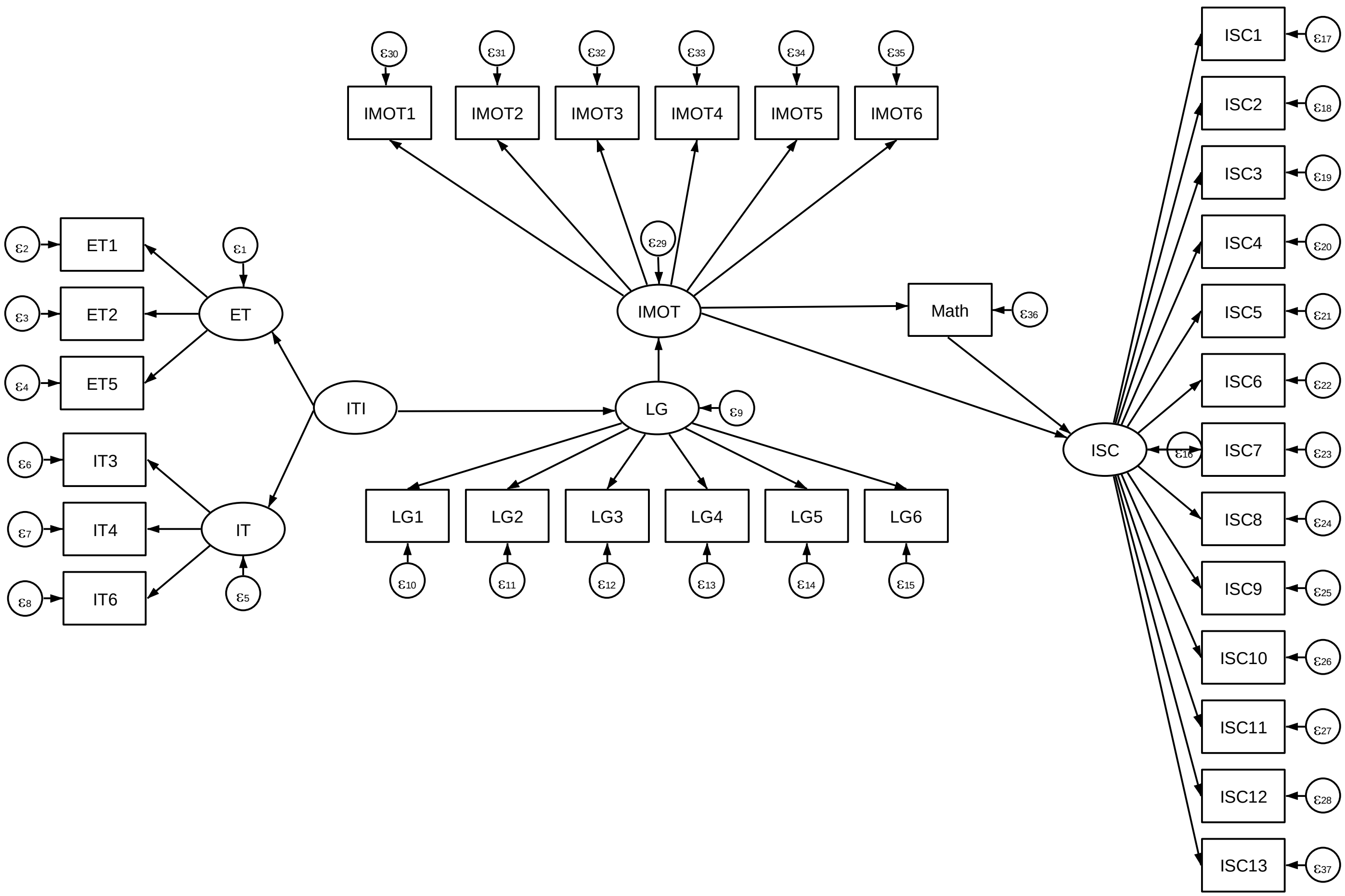

Figure 6. Model 4: Associations among implicit theories of intelligence (ITI), performance-avoidance goals (PAVG), intrinsic motivation (IMOT), math achievement (Math) and interest in STEM careers (ISC)