Gender Differences in Gifted Adolescents' Math/Verbal Self-Concepts and Math/Verbal Achievement: Implications for the STEM Fields

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The current study investigated the gender differences of gifted adolescents' math/verbal self-concept and math/verbal ability by examining the Internal/External Frame of Reference Model (I/E model; Marsh, 1986). The sample consisted of 181 gifted adolescents, ranging in age from 12 to 16 years old. Gifted adolescents' math/verbal ability was measured using their SAT/ACT scores, and math/verbal self-concepts were measured by the Mathematics and Verbal subscales of the Self Description Questionnaire II (SDQ II; Marsh, 1990). Using path analysis, results partially support the I/E model, although no gender differences with regard to the I/E model were found. Implications with regard to the STEM fields are discussed.

Although the gap is not yet closed, males and females at the elementary and secondary level are largely achieving in the fields of science,

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Journal for the Education of the Gifted. Vol. 32, No. 1, 2008, pp. 34–53.

technology, engineering, and mathematics (STEM) at comparable rates (Campbell & Clewell, 1999). However, males and females are not entering STEM fields at rates consistent with their abilities, as males ultimately dominate the STEM career fields. Even if one identifies the most talented young women in the country in the areas of math and science, one cannot assure they will actually enter the fields of math or science (Lubinski & Benbow, 2006). Indeed, gifted females drop out of STEM fields at a much higher rate than gifted males (Johnsen & Kendrick, 2005). As beliefs about innate gender differences in cognitive abilities are now considered obsolete (Linn & Hyde, 1989; Spelke, 2005), researchers are left to wonder what factors influence females' decisions to enter a STEM career field. One's ability level does not seem to be the answer. One's perceptions about one's ability level, though, might provide a key.

Even though girls may like math and are achieving at math, they do not feel as confident as boys do about their abilities in math (American Association of University Women, 1991). For example, Williams and Montgomery (1995) found male students had higher math self-concepts than female students. However, no gender differences were found with regard to math achievement, suggesting that even though girls and boys are achieving at the same rates in math, girls still perceive their math abilities as lower than boys. "Self-perceptions that lead gifted girls to devalue their abilities may limit their future aspirations, and, as a result, decrease the contributions of a significant group in our society" (Kramer, 1991, p. 359). "Until these issues are addressed . . . we will continue to see situations in which women are underrepresented in the majority of technical and scientific careers" (McCormick & Wolf, 1993, p. 87). One model that might explain the differences in gifted males and females perceptions of their mathematics abilities, which in turn might later affect their career choices, is the Internal/External Frame Of Reference Model (I/E model; Marsh, 1986).

Marsh (1986) developed the I/E model to illustrate how individuals' math and verbal self-concepts operate. At the most simplistic level, self-concept can be defined as an idea or set of ideas one has about oneself (Plucker & Stocking, 2001). Self-concept is believed to be multidimensional, and includes three subconstructs: academic, social, and physical. Academic self-concept can be seen as a description and evaluation of one's perceived academic abilities and one's perceived academic competence (McCoach & Siegle, 2002). Academic self-concept is comprised of at least two higher order academic facets, namely a verbal component and a math component (Marsh, Byrne, & Shavelson, 1988).

The I/E model depicts a student's internal and external comparisons of different domains to explain the development of his or her verbal and math self-concepts. The internal comparison refers to how the student compares his or her ability in one domain to his or her ability in another domain. For example, a student might evaluate his or her math ability and compare it to his or her verbal ability. The external comparison concerns the student's perception of his or her own academic ability in comparison to others. For instance, a student may compare his or her verbal skills to a peer of a differing verbal ability (Marsh, 1986).

The I/E model makes several predictions regarding the relationships between math/verbal achievement and math/verbal self-concept (Marsh, 1986). First, achievement in one area should have a direct positive effect on self-concept in the related area (due to the external comparisons) and a negative effect on self-concept in the other area (due to the internal comparisons). For example, a student's verbal achievement would have a positive impact on his or her verbal self-concept and a negative impact on his or her math self-concept. The competing effects of the external and internal comparisons largely cancel each other out and a student's math self-concept may appear to be unrelated to his or her verbal self-concept, although he or she may have very similar mathematics and verbal achievement (Plucker & Stocking, 2001). These hypothesized pathways can be seen in Figure 1.

Several research studies have examined the I/E model. For example, Yeung and Lau (1998) utilized the I/E model to study postsecondary students and replicated the I/E model paths leading from verbal achievement to math self-concept, math achievement leading to math self-concept, and math achievement leading to verbal self-concept. They found a significant correlation between prior achievement in one area and self-concept in the same domain. These data indicated students compare their own ability or competence to other students' abilities in order to create their individual self-con-

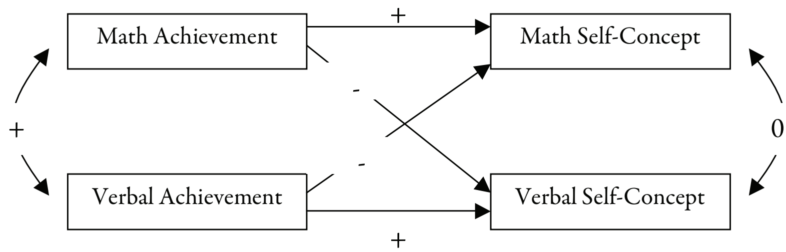

Figure 1. Hypothesized relationship between math/verbal self-concept and math/verbal ability (Marsh, 1986).

cept. Further, the I/E model has been replicated in a sports-related context (Tietjens & Niewerth, 2005), using more than two subject areas (Schilling, Sparfeldt, & Rost, 2004), and using achievement in German rather than in English (Dickhäuser, 2005). The model was examined directly following the announcement of exam results (Möller & Köller, 2001) and reproduced for locus of control studies (Abu-Hilal, 2002). Recently, Marsh and Hau (2004) found support for the I/E model in a study that included students from 26 countries, illustrating the generalizability of the I/E model.

Although the I/E model was not originally tested with gifted students, several researchers have applied the I/E model to samples of gifted students (e.g., Plucker & Stocking, 2001). In addition, researchers have examined the I/E model for possible gender differences (e.g., Skaalvik & Rankin, 1990; Swiatek, 2005). Before turning to the current study, the following review of literature will explore research findings regarding the I/E model and gifted students, as well as gender differences within the I/E model. Further, we will briefly discuss how the I/E model might explain STEM career field choices among gifted males and females.

Gifted Students and the I/E Model

Williams and Montgomery (1995) used the I/E model to examine the paths between verbal/math self-concepts and verbal/math achievement among ninth-grade students who were enrolled in honors courses. Their findings supported the I/E model. The students used internal and external comparisons to assist in the process of determining their verbal and math self-concepts. Plucker and Stocking (2001) used the I/E model to study academically talented students who participated in a summer program, and they, too, found support for the I/E model. They found a significant, positive correlation between math achievement and math self-concept, and between verbal achievement and verbal self-concept. Additionally, there was a significant negative correlation between math achievement and verbal self-concept and between verbal achievement and math self-concept. The I/E model has been replicated with gifted students from other cultures as well. For example, Mui, Yeung, Low, and Jin (2000) found support for the I/E model with a sample of gifted Chinese adolescents.

Gender and the I/E Model

Marsh's (1986) original notion about the I/E model's generalizability is that it likely equally applies to males and females. However, researchers have found mixed results with regard to the applicability of the I/E model to explain the self-concept development of males and females. For example, Skaalvik and Rankin (1990) examined the math and verbal self-concepts of 231 Norwegian sixth-grade students. Math/verbal self-concepts were measured by means of the student's expected success on a particular mathematics or verbal task. Math/verbal achievement was measured by the student's performance on these specific math and verbal tasks.[1] Skaalvik and Rankin (1990) found no significant differences between boys and girls in math achievement or math self-concept, but they did find a significant difference between boys and girls in verbal achievement and verbal self-concept such that girls had a higher verbal self-concept and higher verbal achievement than boys. In addition, Skaalvik and Rankin (1990) found a correlation of 0.63 between math and verbal achievement, which concurred with previous findings. However, verbal and math self-concept was correlated at 0.67, which did not support previous findings regarding the I/E model (Marsh, 1986; Marsh et al., 1988). Further, for girls, verbal achievement negatively affected math self-concept. Skaalvik and Rankin (1995) conducted another study whereby they examined sixth- and ninth-grade Norwegian students. Results involving general math and verbal self-perceptions supported Marsh's I/E model. However, it is important to add that Skaalvik and Rankin's (1990, 1995) participants were not gifted in either study, which means their findings cannot be generalized to the gifted population.

In a nationally representative sample consisting of more than 20,000 participants, Marsh and Yeung (1998) found girls scored higher on verbal achievement, verbal self-concept, and math achievement, but they had lower math self-concept scores than boys. However, Marsh and Yeung did not find gender differences with regard to the I/E model, such that prior verbal and math constructs affected subsequent verbal and math outcomes in a similar manner for girls and boys.

Swiatek's (2005) research examined 2,283 third- through sixth-grade talent search participants. The students were asked to answer questions indicating how capable they felt in an academic area compared to their classmates. Swiatek found no differences between males and females with regard to academic self-concept or academic achievement. As self-concept likely becomes more differentiated with age (Marsh & Shavelson, 1985), these findings are not surprising.

As previously mentioned, Williams and Montgomery (1995) examined the I/E model among a sample of ninth graders enrolled in honors classes. They also examined gender differences within the I/E model. Honors females were more likely to rely on the internal aspect of the I/E model, such that achievement in one area negatively affected self-concept in the other area, and the two areas of self-concept (i.e., math and verbal) were not highly correlated. Honors males, though, were more likely to rely on the external aspect of the I/E model, as the two facets of self-concept were significantly correlated and mathematics achievement had a positive effect on verbal self-concept.

Self-Concept and Career Choice

Individuals are likely to evaluate their abilities and choose a career path based on their perceived capacity to be successful within a particular occupation. In other words, one's self-concept likely affects his or her career choice. Many researchers have supported this notion (e.g., Farmer, 1985; Gottfredson, 2002; Holland, 1973; Lent, Brown, & Hackett, 1994, 2000; Rottinghaus, Lindley, Green, & Borgen, 2002). For example, Marsh and O'Neill (1984) found females' aspirations to attend college or university were moderately correlated with general academic self-concept ($r = 0.31, p < 0.01$). Further, self-concept affects course selection, which affects a student's aspired major in postsecondary education (Nagy, Trautwein, Baumert, Köller, & Garrett, 2006). Trusty and Ng (2000), for example, examined students' mathematics self-efficacy and English self-efficacy and found students' mathematics self-efficacy was predictive of their postsecondary educational choices. Thus, students' perceptions of their verbal and math abilities within the I/E model may serve as a framework for understanding why some students enter STEM fields and some students do not. High math self-concept may lead to a career in a STEM field and a low math self-concept may deter students from a career in a STEM field. Gender differences within the I/E model would be particularly illustrative of potential career-related decisions.

The Current Study

The purpose of the current study is to examine the I/E model among gifted males and females in order to assess gender differences in math/verbal self-concept and math/verbal achievement and to examine the role of internal and external comparisons among gifted adolescents in forming their self-concepts. Although information regarding the STEM areas will not be empirically addressed, implications about the STEM areas that come from this research will be discussed. This study will address several questions that arise when researching gifted adolescents' academic self-concept. For instance, do gifted adolescent females and males differ with regard to math/verbal achievement and math/verbal self-concept? If so, how? Further, do gifted adolescents use external and internal comparisons in order to establish their math and verbal self-concepts? Based on previous research, our hypotheses are as follows:

1. Achievement in one area will positively affect one's self-concept in the same area but will negatively affect one's self-

concept in the noncorresponding area, as outlined by the I/E model.
2. One's math and verbal self-concepts will not be related, as outlined by the I/E model.
3. The I/E model will be experienced differently by gifted males and gifted females.

This study is important for two main reasons. First, although variations on this study have been conducted, specifically understanding gender differences among gifted adolescents will contribute to literature pertaining to gifted adolescents, the I/E model, multidimensional self-concept, and the math and verbal achievement of gifted students. Second, in a time when gifted females are failing to enter STEM fields and/or dropping out of STEM fields at a fast rate, the I/E model might be able to predict why this is happening. A clear understanding of the gender differences within the development of both math and verbal self-concepts might provide some explanation for why gifted females opt out of careers in the STEM areas, particularly if gifted females and gifted males are achieving in math at the same rate.

Method

Participants

Participants were recruited from a residential summer camp for mathematically and verbally gifted students held at a comprehensive university in the south. The summer camp is a 3-week residential program for gifted students entering the 8th, 9th, 10th, or 11th grades the following school year. To qualify for participation in this summer camp, students must have been eligible for a talent search (e.g., the Duke Talent Identification Program) within the past 4 years. The summer camp involved 6 hours of class and 1 hour of study hall per day, 5 days a week, for 3 weeks. The students had a variety of courses from which to choose (e.g., Humanities, Psychology, Mathematics), and they enrolled in only one course. The students also engaged in various social activities (e.g., board games, athletic activities, a talent show) after class each day and on weekends.

Parental consent was obtained from 269 of approximately 300 participants. Because we used a design that included both Mathematics and Verbal subscale scores, if participants only reported one score, they were eliminated from this study. Thus, because of missing data, a total of 181 gifted adolescents were included in this study. The sample included 78 females (43.1%), 102 males (56.4%), and one person who did not report his or her gender. Participants' ages ranged from 12 to 16 years with a mean of 14.14 (SD = 1.18). The participants ranged from 7th to 10th grades, with 49 (27.1%) participants entering grade 7, 46 (25.4%) entering grade 8, 52 (28.7%) entering grade 9, and 34 (18.8%) entering grade 10.

Materials

Demographic information. Participants were given a demographic questionnaire to assess gender, age, and grade level.

Math and verbal achievement. Participants' math and verbal achievement were assessed using their SAT/ACT scores. Because participants provided either SAT subscale scores (Verbal and Mathematics) or ACT subscale scores (Verbal, Mathematics, and Science), or both (n = 2), the scores had to be converted to a common scale for analysis. Thus, the ACT subscale scores were transformed into z-scores, which were then transformed into equivalent SAT subscale scores.

Math and verbal self-concepts. The Self Description Questionnaire II (SDQ-II) was designed to measure the self-concepts of young adolescents aged 13–17 and is theoretically based on the notion that self-concept is multidimensional and hierarchically structured (Marsh, 1990; Shavelson, Hubner, & Stanton, 1976). The SDQ-II measures self-concept in the following areas: Mathematics, Verbal, General School, Physical Abilities, Physical Appearance, Same-Sex Peer Relations, Opposite-Sex Peer Relations, Parent Relations, Emotional Stability, Honesty/Trustworthiness, Total Academic, and General Self. Scores on each subscale of the SDQ-II range from 1

(*False*) to 6 (*True*). Thus, a higher score on the scale reflects a higher self-concept, whereas a lower score reflects a lower self-concept (some items are reverse coded). Extensive support for the reliability and validity of the SDQ-II has been reported in other research (see Gilman, Laughlin, & Huebner, 1999; Plucker, Taylor, Callahan, & Tomchin, 1997).

For the purposes of this study, only the Mathematics and Verbal subscales were used to measure math and verbal self-concept. The Mathematics subscale measures ability, enjoyment, and interest in mathematics and reasoning. A sample item from this subscale is, "I do badly in tests of mathematics" (Marsh, 1990, p. 5). From the normative sample, internal consistency was reported as 0.90 and factor loadings ranged from 0.72 to 0.80. Within the current sample, the reliability coefficient for the Mathematics subscale was 0.93. The Verbal subscale measures ability, enjoyment, and interest in English and reading. A sample item from this subscale is, "I learn things quickly in English classes" (Marsh, 1990, p. 5). Internal consistency was reported as 0.86 and factor loadings ranged from 0.53 to 0.75. Within the current sample, the reliability coefficient for the Verbal subscale was 0.87.

Procedure

Parental consent was obtained prior to the start of the summer program. During the first night at the program, students whose parents gave consent were invited to take part in the study.

Results

To examine the I/E model among gifted males and gifted females in order to assess gender differences in math/verbal self-concept and math/verbal achievement, several analyses were used. First, a series of paired-samples *t*-tests and analyses of variance (ANOVAs) were utilized to examine the differences between participants' achievement test scores and self-concept scores, as well as to analyze the differences in participants' achievement test scores by gender. Descriptive statistics for the achievement test scores and self-concept scores can be found

Table 1

Descriptive Statistics for the Math Achievement, Verbal Achievement, Math Self-Concept, and Verbal Self-Concept Variables by Gender

	All		Males		Females	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Math Achievement	491.68	77.09	496.76	79.14	485.03	74.31
Verbal Achievement	527.40	91.02	512.34	98.94	547.12	75.64
Math Self-Concept	4.78	1.13	4.84	1.04	4.70	1.24
Verbal Self-Concept	5.01	0.84	4.87	0.86	5.20	0.78

Table 2

Intercorrelations Between the Achievement and Self-Concept Variables

Variable	MA	VA	MSC	VSC
Math Achievement	—			
Verbal Achievement	.065	—		
Math Self-Concept	.276**	-.165*	—	
Verbal Self-Concept	-.157*	.302**	-.164*	—

Note. MA = math achievement, VA = verbal achievement, MSC = math self-concept, VSC = verbal self-concept. * $p \leq 0.05$. ** $p \leq 0.001$.

in Table 1. A correlation matrix of the achievement test scores and the self-concept scores can be seen in Table 2. Regarding the achievement test scores, participants scored higher on the SAT Verbal than on the SAT Math, evidenced by a paired samples *t*-test that revealed the mean difference of 35.66 was statistically significant, $t(180) = 4.169$, $p < 0.001$ (two-tailed), $d = 0.43$. In terms of math achievement, there was no significant difference between females' scores ($M = 485.03$) and males' scores ($M = 496.76$), $F(1,178) = 1.03$, $p = 0.31$ (two-tailed). However, females' verbal achievement scores ($M = 547.12$) were significantly higher than males' verbal achievement scores ($M = 512.34$), $F(1,178) = 6.65$, $p < 0.05$ (two-tailed), $d = 0.40$.

A paired samples *t*-test revealed the mean difference of 0.23 between all participants' math self-concept scores and verbal self-concept scores was significant, $t(180) = -2.04$, $p < 0.05$ (two-tailed), $d = 0.23$, indicating that, on average, participants' verbal self-concept scores were significantly higher than their math self-concept scores. No gender difference was found for math self-concept scores (female $M = 4.70$, male $M = 4.84$), $F(1,178) = 0.69$, $p = 0.41$ (two-tailed). However, females' verbal self-concept scores ($M = 5.20$) were significantly higher than males' ($M = 4.87$), $F(1,178) = 6.981$, $p < 0.01$ (two-tailed), $d = 0.29$.

To examine the I/E model, a path analysis was conducted by testing a series of simultaneous regression models. Specifically, math self-concept scores were regressed on math achievement scores and verbal achievement scores, and verbal self-concept scores were regressed on math achievement scores and verbal achievement scores. The standardized regression coefficients are reported below and all tests of significance are two-tailed. For the most part, the model responded as expected. Math achievement was found to be positively associated with math self-concept, $\beta^S = .288$, $p < 0.001$, and negatively associated with verbal self-concept, $\beta^S = -.177$, $p = 0.013$. Additionally, verbal achievement was positively associated with verbal self-concept, $\beta^S = .313$, $p < .001$, and negatively associated with math self-concept, $\beta^S = -.183$, p = 0.010. Contrary to the Marsh model, however, a significant negative correlation was found between math self-concept and verbal self-concept, $r(179) = -1.64$, $p = 0.028$. A path diagram of both the standardized and unstandardized coefficients on the entire sample can be found in Figure 2.

To assess gender differences, Gender X Math Achievement and Gender X Verbal Achievement interaction variables were created. When added as predictors to the regression analyses, none of the gender interaction variables were found to be significant. Accordingly, no systematic differences were found in the way males and females form their math and verbal self-concepts within the I/E model. The details of the analyses are provided in Table 3.

Discussion

The purpose of the current study was to examine the I/E model among gifted males and females in order to assess gender differences in math/

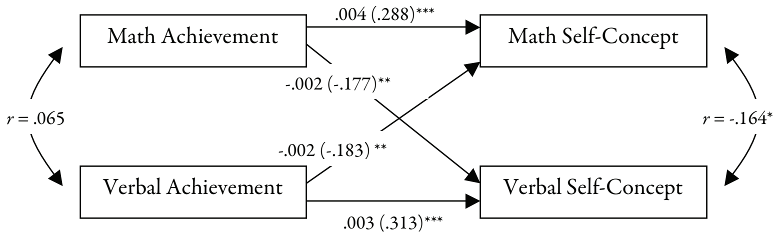

Figure 2. Path diagram of standardized and unstandardized regression coefficients on the entire sample.

Note. Standardized path coefficients are provided in parentheses. r = correlation coefficient. $*p \leq 0.05$. $** p \leq 0.01$. $*** p \leq 0.001$.

Table 3

Summary of Gender Interaction Variables Predicting Math Self-Concept and Verbal Self-Concept

Criterion Variable	Interaction Variable	β	SE_{β}	β^{S}	*Sig.*
Math Self-Concept					
	Gender X Math Achievement	-.002	.002	-.398	.277
	Gender X Verbal Achievement	.002	.001	.387	.266
Verbal Self-Concept					
	Gender X Math Achievement	.001	.001	.354	.326
	Gender X Verbal Achievement	-.001	.001	-.453	.187

Note. β is an unstandardized coefficient; SE_{β} is the Standard Error of β; β^{S} is a fully standardized coefficient.

verbal self-concept and math/verbal achievement and to examine the role of internal and external comparisons among gifted adolescents in forming their math and verbal self-concepts. Results suggest significant differences between males and females with regard to verbal achievement scores, no differences with regard to math achievement scores, significant differences with regard to verbal self-concept scores, and no differences with regard to math self-concept scores. Females scored higher than males on the measures of verbal achievement and verbal self-concept. However, results suggest males and females within the current sample do not experience differences within the I/E model with regard to the way their math and verbal self-concepts develop. Although significant, the relationships between the variables in this study are all weakly related (see Figure 2).

The I/E model was only partially corroborated in the current study, thus supporting only one of the first two of our hypotheses. Consistent with the I/E model, achievement in one area was positively correlated with one's self-concept in the same area and was negatively correlated with one's self-concept in the noncorresponding area. However, students' math and verbal self-concepts were negatively correlated in the current study, which differs from the I/E model. The negative correlation between students' math and verbal self-concepts might be explained, at least in part, by the notion of "negative interdependence," or the idea that two areas of abilities are unrelated. As Möller, Streblow, and Pohlmann (2006) suggest, the belief in the negative interdependency between math and verbal ability, or that the two areas of ability are not related, can influence one's corresponding perceptions of abilities in those domains. Some students may believe math and verbal abilities are unrelated, thus influencing the perceptions of their abilities in those realms. Further, if one's actual abilities in math and verbal disciplines are unrelated, as evidenced in the current study (a significant difference was found between participants' math and verbal achievement scores), the correlation between math and verbal self-concept is more likely to be negative (Rost, Sparfeldt, Dickhäuser, & Schilling, 2005).

Results from the current study do not suggest gender differences within the I/E model, thus not supporting our third hypothesis, but providing support for Marsh's (1986) original notion that the I/E model is equally generalizable to males and females. Although females in the current study had higher verbal achievement scores and reported higher verbal self-concept scores than males, which is consistent with other research (e.g., Skaalvik & Rankin, 1990), these differences did not affect the math self-concept in a different manner for males and females. Other researchers also have failed to find evidence for gender differences with regard to the I/E model (e.g., Marsh & Yeung, 1998).

Limitations and Directions for Future Research

The current study is limited in generalizability because the data were collected at a single point in time and from a single summer program. Gender differences, or the lack thereof, among gifted adolescents within the I/E model have not been readily explored in previous research studies but should be replicated with other samples before conclusions can be drawn regarding the development of adolescents' math and verbal self-concept.

Future research should examine the notions of the negative interdependencies of math and verbal abilities, or the belief that these abilities are not related. As Möller et al. (2006) suggested, the belief in the negative interdependency between math and verbal ability can influence one's corresponding perceptions of abilities in those areas, which would serve as an extension of the I/E model. Further, Hannover and Kessels (2004) found students avoid particular subject areas when they believe in negative interdependency. Coupled with the notion that self-concept likely affects course selection, gifted females with feelings of negative interdependency might avoid courses in the STEM areas, and thus careers in the STEM areas, irrespective of the I/E model. In other words, a high verbal self-concept may simply offset perceptions of ones' abilities in math and lead one into careers unrelated to the STEM areas.

Indeed, a recent review of 35 years of longitudinal research from the Study of Mathematically Precocious Youth (SMPY) suggests mathematically gifted females are more often both mathematically *and* verbally gifted than mathematically gifted males (Lubinski & Benbow, 2006). If gifted young women are endowed with high abilities in verbal and mathematical areas, they may simply have more options with regard to a career, unlike males who may be limited to one area. However, if these gifted women pursue careers outside of the STEM areas, perhaps we should heed the advice of Lubinski and Benbow and see this "as a contribution to society, not a loss of talent" (p. 316).

More research is needed so that the I/E model might be extended to allow for examinations of gifted students' beliefs about negative interdependency in order to more fully understand the development of math and verbal self-concepts over time. Future research should incorporate a longitudinal method to specifically examine students' self-concepts, abilities, and career-related decisions with regard to the STEM areas to better understand the career patterns of gifted males and gifted females. There are many questions that remain to be answered: Why do gifted females drop out of STEM fields at much higher rates than gifted males? Why is it that females fail to enter STEM fields at rates consistent with their abilities? Why do some of the most talented women eschew careers in the STEM fields? Due to the complexity of the issues at hand, clarity will only come with continued inquiry.

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Author Note

Research for this article was supported by a Faculty Scholarship administered to the first author by Western Kentucky University.

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End Note

1. It is noteworthy to add that these Norwegian students do not receive any grades during the first 6 years of elementary school; therefore, they do not have any standardized measures of achievement.