

# Influences of Self-Perceived Competence in Mathematics and Positive Affect toward Mathematics on Mathematics Achievement of Adolescents in Singapore

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This study, drawing on data from the Trends in International Mathematics and Science Study (TIMSS) 2007, examined the influences of self-perceived competence in mathematics and positive affect toward mathematics on mathematics achievement of adolescents in Singapore. Ordinary least squares (OLS) regression analyses revealed the positive influences of self-perceived competence in mathematics and positive affect toward mathematics on mathematics achievement of adolescents in Singapore. Implications of the findings for policy and practice are discussed.

Numerous studies have examined the influences of domain specific academic self-concepts (e.g., mathematics self-concept and verbal self-concept) on their corresponding measures of achievement. However, academic self-concept is multidimensional in nature, and domain specificity is one of the facets of multidimensional academic self-concept (see Arens, Yeung, Craven, & Hasselhorn, 2011; Marsh, Craven, & Debus, 1999). Marsh (1992) posited that students' self-concept may comprise of affective as well as competency dimensions. Later, Marsh et al. (1999) found empirical support for the multidimensional facets of academic self-concept at the within-domain level. Specifically, the authors found empirical evidence from two separate studies for the separation of competence and affect components of mathematics, reading, and school self-concepts among school children in Australia.

Recently, Arens et al. (2011) found empirical support for the two-fold multidimensionality of academic self-concept (mathematics, verbal, and general school self-concepts)—domain specificity and separation between competence and affect components—among school children in Germany. Theories pertaining to motivation, self-determination theory (see Deci & Ryan, 2000), and expectancy-value theory (see Eccles & Wigfield, 1995) as well postulate that students' self-perceived academic competence and affect toward learning be treated as two separate constructs. Thus, the multidimensionality of academic self-concept also includes two separate dimensions of academic self-concept: a self-evaluative/cognitive dimension—competence—and an affective/motivational dimension—affect (within-domain level; Arens et al., 2011; Marsh et al., 1999).

Although a substantial body of research has examined the relationships between domain-specific academic self-concepts and their corresponding measures of achievement (see Marsh & Martin, 2011, for a review), only one study to our knowledge has specifically explored the relationships between competence and affect components of academic self-concept and achievement using Marsh and colleagues' theoretical model of academic self-concept. Arens et al. (2011) explored the latent factor correlations between competence and affect components of academic self-concept and achievement among school children in Germany. Mathematics and verbal achievement were more strongly correlated with students' self-perceived competence in mathematics and German than with their affect toward mathematics and German.

Shen and Pedulla (2000), drawing on data from the Third International Mathematics and Science Study and employing Bandura's (1997) self-efficacy theory, explored the relationships between self-perceived competence in mathematics and science and student achievement. Within country data suggested a positive relationship between self-perceived competence in mathematics and science and student achievement. Nonetheless, the authors used a single item ("I usually do well in mathematics and science") to measure students' self-perceived competence in mathematics and science. Neither Arens et al. (2011) nor Shen and Pedulla (2000) have examined the predictive effects of competence and affect components of academic self-concept on student achievement.

However, studies that employed other theoretical frameworks, such as self-determination theory (see Deci & Ryan, 2000) and achievement goal theory (see Maehr & Zusho, 2009), have demonstrated the positive predictive effects of self-perceived academic competence on achievement outcomes (e.g. Cho, Weinstein, & Wicker, 2011; Ferla, Valcke, & Schuyten, 2010). Similarly, studies have also documented the positive effects of students' affective self-perceptions on their learning and achievement (e.g. Lau & Roeser, 2008; Nieswandt, 2007).

Nevertheless, no study to date has examined specifically the predictive effects of competence and affect components of mathematics self-concept on mathematics achievement. A better and deeper understanding of the effects of competence and affect components of mathematics self-concept on mathematics achievement may help educators to develop appropriate educational interventions with a view to enhancing students' achievement in mathematics. As the Organization for Economic Cooperation and Development (OECD, 2007) notes:

The performance of a country's best students in mathematics and related subjects may have implications for the role that the country will play in tomorrow's advanced technology sector, and for its overall international competitiveness. Conversely, deficiencies among lower-performing students in mathematics can have negative consequences for individuals' labour market and earnings prospects and for their capacity to participate fully in society. (p. 323)

Given the importance of mathematical competence and the dearth of research on the impact of competence and affect components of academic self-concept on academic achievement, the purpose of the present study was to explore the influences of self-perceived competence in mathematics and positive affect toward mathematics on mathematics achievement of adolescents in Singapore. Specifically, the study addressed the research question: How well do self-perceived competence in mathematics and positive affect toward mathematics predict mathematics achievement among adolescents in Singapore?

## Method

### *Data*

Data for the study were drawn from the Trends in International Mathematics and Science Study (TIMSS) 2007 dataset. TIMSS 2007, sponsored by the International Association for the Evaluation of Educational Achievement (IEA), is the fourth in a series of comparative international studies assessing the mathematics and science performance of both fourth and eighth graders. In Singapore, 4599 eighth graders (male = 2353, female = 2246) from 164 schools took part in TIMSS 2007. The mean age of participants was 14.39 years.

## Measures

*Outcome variable.* Mathematics achievement score (five plausible values) at eighth grade level on the TIMSS 2007 assessment was the dependent variable in the study. Since students were administered too few items in each specific content area, the TIMSS 2007 developed plausible values as a computational approximation to obtain consistent and precise estimates of students' ability (IEA, 2009a). "Plausible values are multiple imputations of the unobservable latent achievement for each student" (Wu, 2005, p. 114). The mathematics achievement score is reported on a scale from 0 to 1,000, with the TIMSS scale average set at 500 and standard deviation set at 100 (Olson, Martin, & Mullis, 2008). The IEA IDB analyzer (Version 2.0; IEA, 2009b)—a plug-in for the Statistical Package for the Social Sciences (SPSS) that allows the user to combine and analyze data from TIMSS 2007—along with IBM SPSS Statistics 19 was used to run models for each of the five plausible values, producing their average values and correct standard errors.

*Predictor variables.* The TIMSS 2007 had 8 items pertaining to students' affect toward mathematics and their self-perceived competence in mathematics. The current study used these 8 items to measure adolescents' multiple dimensions of mathematics self-concept. All items were rated on a four-point Likert scale ranging from 1 (*disagree a lot*) to 4 (*agree a lot*). Negatively worded items were reverse scored. Maximum-likelihood extraction with oblique rotation was performed on all the 8 items. Two factors were extracted from the 8 items, and these two factors accounted for 73% of the variance. Loadings of all variables on factors were above the cutoff of 0.45 (20% of variance). The factor solutions met multiple additional criteria such that each factor contained a minimum of three items, exhibited sufficient internal consistency, and was interpretable. Cronbach's  $\alpha$  was used to measure the internal consistency of the scale items. The two factors were *positive affect toward mathematics* (four items;  $\alpha = 0.90$ ) and *self-perceived competence in mathematics* (four items;  $\alpha = 0.82$ ). The student demographic variables were gender (1 = female; 0 = male), language spoken at home (speaking the language of the assessment at home; 1 = *never* to 4 = *always*), and parental education (1 = *less than lower secondary education* to 5 = *university education*).

## Results

The descriptive statistics and the correlation between outcome variable and predictor variables are presented in Table 1. All predictor variables were positively correlated with mathematics achievement of adolescents in Singapore. To address the purpose of the study, ordinary least squares (OLS) regression analyses were conducted (see Table 2). Mathematics achievement was the dependent variable. Gender, language spoken at home, parental education, self-perceived competence in mathematics, and positive affect toward mathematics were the independent variables. Given the two-stage stratified cluster sample design of the TIMSS 2007 assessment, replicate weights—based on the jackknife repeated replication technique—were used to generate unbiased parameter estimates and their correct standard errors.

Table 1  
*Descriptive Statistics and Correlations*

	<i>M</i>	<i>SD</i>	Mathematics Achievement ( <i>r</i> )
Gender	0.51	0.50	0.05
Language spoken at home	2.65	0.93	0.21
Parental education	3.51	1.17	0.31
Self-perceived competence in mathematics	2.69	0.78	0.44
Positive affect toward mathematics	2.96	0.83	0.33

*Note.* All correlation coefficients (*r*) are statistically significant,  $p < 0.05$ .

The overall regression model predicting mathematics achievement from student demographic variables, self-perceived competence in mathematics, and positive affect toward mathematics was statistically significant, adjusted  $R^2 = 0.27$ ,  $F(5, 3606) = 266.30$ ,

$p < 0.001$ , 95% confidence interval (CI) [0.24, 0.29],  $f^2 = 0.37$ . Student demographic variables were positively associated with mathematics achievement. Female adolescents scored statistically significantly higher than their male counterparts on mathematics achievement. Adolescents who often spoke the language of the assessment at home had statistically significantly higher scores on the TIMSS 2007 mathematics assessment than their peers who infrequently spoke the language of the assessment at home. Similarly, adolescents whose parents had higher levels of education tended to have higher scores on the TIMSS 2007 mathematics assessment than their peers whose parents had lower levels of education.

Self-perceived competence in mathematics and positive affect toward mathematics were also positively associated with mathematics achievement. Adolescents who perceived themselves to have higher mathematical competence performed statistically significantly better in mathematics than did their peers who perceived themselves to have lower mathematical competence. Likewise, adolescents who reported higher levels of positive affect toward mathematics performed statistically significantly better in mathematics than did their peers who reported lower levels of positive affect toward mathematics.

Table 2  
*Ordinary Least Squares (OLS) Regression Analyses Predicting Mathematics Achievement*

	<i>B</i>	<i>SE</i>
Constant	380.39	11.35
Gender	14.99	3.93
Language spoken at home	9.12	2.07
Parental education	16.28	1.47
Self-perceived competence in mathematics	41.17	2.37
Positive affect toward mathematics	7.15	2.71
Adjusted $R^2$		0.27
$f^2$		0.37
<i>F</i>		266.30*

*Note.* All coefficients are statistically significant,  $p < 0.05$ . \* $p < 0.001$ .

## Discussion

The purpose of the study was to examine the influences of self-perceived competence in mathematics and positive affect toward mathematics on mathematics achievement of adolescents in Singapore. The study revealed the positive influence of self-perceived competence in mathematics on mathematics achievement. Because self-perceived academic competence precedes intrinsic motivation (Losier & Vallenard, 1994), there is growing evidence that greater self-perceived academic competence would enhance students' intrinsic motivation, which, in turn, would promote their academic achievement (Zisimopoulos & Galanaki, 2009).

Moreover, unlike students with low self-perceived academic competence, students who are mastery goal-oriented and who perceive themselves to have high academic competence may employ a more adaptive learning strategy (Cho et al., 2011). The use of an adaptive learning strategy may help students with high self-perceived academic competence to perform significantly better than students with low self-perceived academic competence. Further, students with high self-perceived academic competence tend to adopt high-performance approach goals, which, in turn, enhance their academic achievement (Cho et al., 2011).

The findings of the study also revealed the positive influence of positive affect toward mathematics on mathematics achievement, suggesting that boosting students' positive affect toward mathematics may help to improve their achievement in mathematics. There is mounting evidence that self-concept enhancement intervention programs would help to improve the self-concepts of adolescents in educational settings (e.g. O'Mara, Green, & Marsh, 2006; O'Mara, Marsh, Craven, & Debus, 2006).

However, self-concept enhancement intervention programs are not generally designed to cater to the needs of students in terms of their self-perceived competence and affect. In other words, such educational interventions often fail to identify competence and affect as two separate dimensions of academic self-concept. The findings of the present study point out the need to treat competence and affect as two separate components of academic self-concept. Hence, self-concept enhancement intervention programs may need to redesign such interventions by incorporating competence and affect components of academic self-concept as two separate constructs.

To enhance students' self-perceived competence in mathematics, mathematics teachers may need to build students' confidence in their ability to do well in mathematics. Insofar as students experience feelings of autonomy and competence during classroom instruction, they tend to be intrinsically motivated toward school and academics (Jang, Reeve, & Deci, 2010). When students are intrinsically motivated, they tend to learn better in school and become more creative on tasks requiring conceptual understanding (Niemic & Ryan, 2009).

Because teacher autonomy support during classroom instruction may help enhance students' perceived academic competence and academic engagement (see Reeve, Jang, Carrell, Jeon, & Barch, 2004, for a review), it is important to develop autonomy-supportive mathematics teachers rather than controlling teachers. To create autonomy-supportive classrooms, teachers may need to gain knowledge, skills, and training in how to be more autonomy supportive toward their students during classroom instruction (Reeve & Assor, 2011). Meta-analyses have demonstrated the effectiveness of such intervention programs in developing an autonomy-supportive motivating style among teachers (e.g., Su & Reeve,

2011). Hence pre-service and in-service teacher training programs may need to design and implement appropriate autonomy-supportive intervention programs with a view to developing autonomy-supportive mathematics teachers, who are capable of fostering their students' perceived competence in mathematics. Given the positive influences of positive affect toward mathematics on adolescents' mathematics achievement, the mathematics teachers may also need to develop and implement appropriate educational interventions to boost their students' positive affect toward mathematics.

Self-concept enhancement intervention programs, however, may not alone effectively help students to improve their achievement in mathematics. To be effective, skills training interventions need to be designed and implemented in conjunction with self-concept enhancement interventions (see O'Mara et al., 2006). Indeed, skills training interventions aimed at developing mathematics skills may benefit underachieving students.

In conclusion, the results of the study suggest the key roles that self-perceived competence in mathematics and positive affect toward mathematics may play in influencing the mathematics achievement of adolescents in Singapore. Developing and implementing appropriate educational interventions with a view to enhancing adolescents' self-perceived competence in mathematics and positive affect toward mathematics may not only improve adolescents' achievement in mathematics but also their labour market outcomes.

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