GENDER DIFFERENCES IN ACADEMIC PSYCHOSOCIAL FACTORS ASSOCIATED WITH MATH ACHIEVEMENT

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ABSTRACT
This study examined gender differences in influential antecedent learning factors that are associated with math achievement. Using the dataset extracted from the Educational Longitudinal Study of 2002, structural equation modeling yields three major findings: (a) social economic status (SES), educational aspiration for attaining an educational degree, total AP/IB math courses, and the degree of advanced math course taking are significantly related with math self-efficacy (p<. 001); (b) female students have better preparation in math through taking advanced math courses (p<.001) and have higher educational aspiration in obtaining advanced degrees (p<.001), while having significantly lower math self-efficacy than male students (p<.001); and (c) given the finding that female students have lower math achievement than male students (p<.001), math self-efficacy is the most critical antecedent learning factor for female students affecting math achievement. These results suggest that for female students, how to enhance math self-efficacy is a critical matter to improve math achievement.

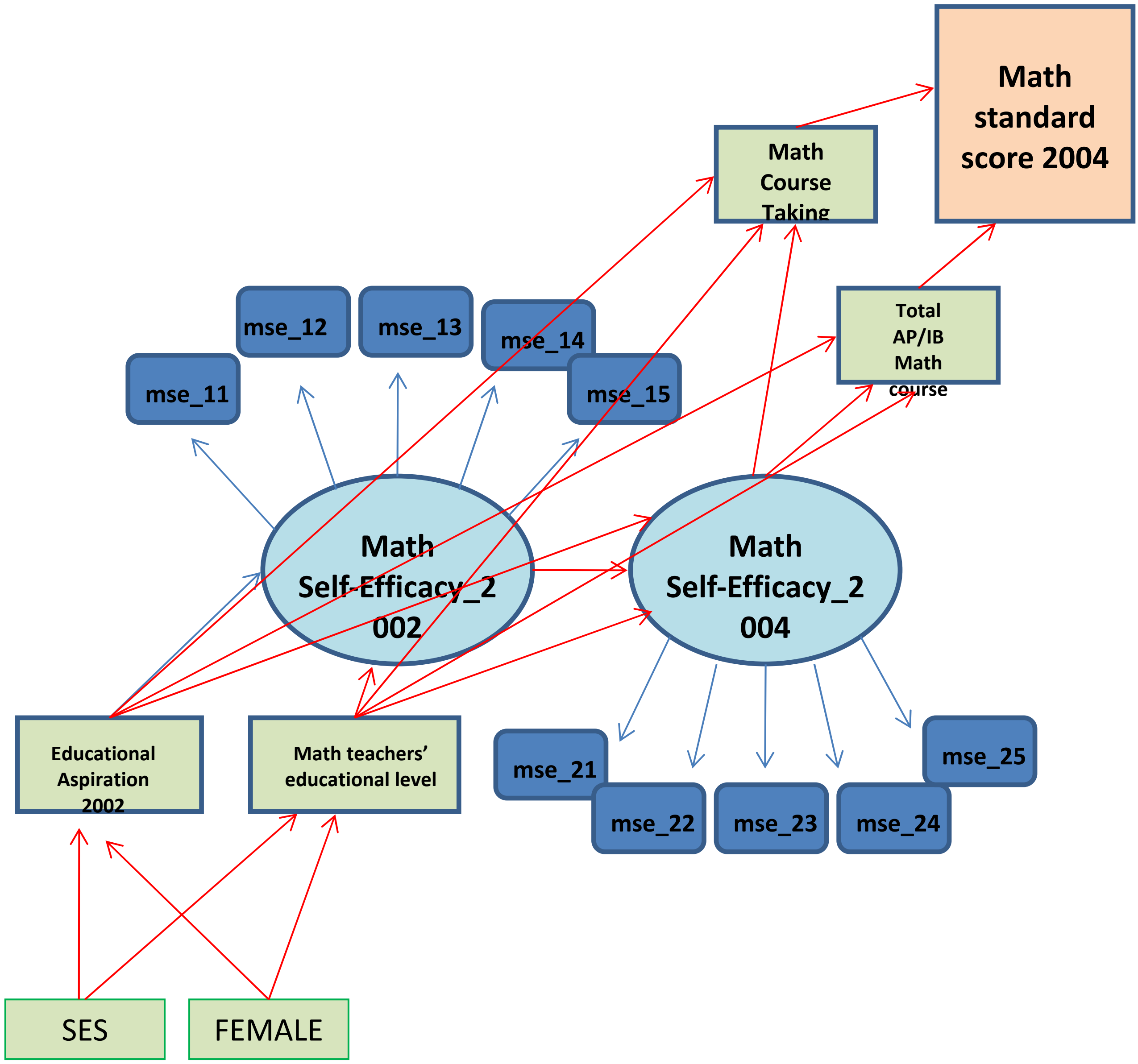
INTRODUCTION
While a sufficient supply of knowledgeable and skilled science technology, engineering, and math (STEM) workers contributes to U.S. economic growth (U.S. Department of Labor, 2007), the number of knowledgeable and skilled STEM workers who have postsecondary degrees in STEM fields has decreased over the past decade (U.S. Census Bureau, 2010). One of the dire facts related to the shortage of STEM workforce is the minority status of female students in STEM fields. The NSF (2007) from the Bureau of Labor Statistics revealed that while the percentage of women in the labor force was 46.4, female engineers represented only 11.1 percent of all engineers. Also, the percentage of female mathematical and computer scientists decreased from 31.0 in 1983 to 25.6 in 2007, although the overall ratio of women in the workforce increased from 43.7 % in 1983 to 46.4% in 2007 (NSF, 2007). Thus, how to encourage female students to choose STEM college majors and careers is a prime matter for educators and policy makers. A wealth of literature indicates that math achievement is a significant factor for students to choose STEM major choice in college (Astin & Astin, 1992; Besterfield-Sacre, Arman, & Sgynabm 1997; French, Immekus, & Oakes, 2005; Levin & Wyekoff, 1998; Nicholls, Wolfe, Besterfield-Sacre, & Larpkiattaworn, 2007; Veenstra, C.P., Dey, E.L., & Herrin, G.D., 2008). Also, it is well documented that math self-efficacy is another critical factor associated with STEM major choices in postsecondary settings (Betz & Hackett, 1983; Hackett & Bets, 1981; Hackett & Betz, 1983; Hackett & Campbell, 1987; Hyde, Fennema, & Ryan, 1990; Lent, Lopez, Bieschke, 1991; O'Brien, Martinez-Pons, & Kopala, 1999). In general, self-efficacy is considered a predictor of students' academic achievement across academic areas and levels (Pajares & Urdan, 2006) as well as students' college major choice and career choices (Brown & Lent, 2006), which is well applied to the social cognitive career theory (SCCT). Conceptually framing the SCCT, several studies discovered the association of math achievement, math self-efficacy, and STEM major and career choices, paying particular attention to gender differences. However, few studies focus on how the antecedent learning factors, other than math self-efficacy, are associated with math achievement based on a large scale.

To address these issues, this study will respond to the following research questions: a) What are the learning factors affecting math achievement? b) To what extent is gender associated with the learning factors? The national profile provides recommendations to educators, policy makers, parents, and female students themselves regarding how learning environments and processes can improve the math achievement of female students, which causes more female students to choose STEM majors in college.

CONCEPTUAL FRAMEWORK
The hypotheses of this study are (a) math self-efficacy will affect the math achievement of female students; (b) a variety of academic and psychosocial factors such as the degree of taking advanced math courses and the educational aspiration of getting advanced educational degrees will influence the math self-efficacy of female students; and (c) students' background factors (i.e., gender, social economic status (SES)) are associated with the academic and psychosocial factors. These hypotheses are established based on the social cognitive career theory (SCCT). SCCT (Lent, Brown, and Hackett, 1994) indicates that personal input (e.g., gender, racial/ethnicity background, disability status, etc) and environmental factors (e.g., social economic status, teacher support, etc) are associated with learning processes, impacting on learners' self-efficacy, academic performance, and career

choices or goals. Through structural equation modeling (SEM), this study will examine how well SCCT fits into the proposed model (Figure 1).

Figure 1. Math Achievement Model of Female Students



METHOD

In the dataset of the Educational Longitudinal Study of 2002 (ELS 2002/06), a sample of 8,147 female and 8,050 male students who were in 10th grade in 2002 was collected to examine gender differences in academic and psychosocial factors affecting math achievement. The gender and SES of a student are the exogenous variables in the proposed model (See Figure 1). A variety of academic and psychosocial factors are regarded as mediator variables. As shown in Figure 1, educational aspiration in attaining educational degrees, the degree of taking advanced math courses, total number of AP/IB math courses, and educational levels of math teachers are associated with math self-efficacy level, which has an effect on the math achievement level. Math self-efficacy is a latent variable that has been constructed by explanatory factor analysis (EFA) and confirmatory factor analysis (CFA). The observed variables that explain the math self-efficacy latent variable were collected in 2002 and 2004, and thus, in this proposed model, there are two sequential math self-efficacy latent variables (i.e., math self-efficacy in 2002 and 2004). The outcome variable is a math standard score accessed in 2004. SEM is an appropriate statistical method because (a) this study examines relationships among academic and psychosocial factors which have an effect on math achievement; (b) this study tests whether the SCCT fits into the proposed model; and (c) the proposed model includes latent variables (i.e., math self-efficacy).

RESULTS

Based on the goodness of fit (i.e., CFI = 0.95, RMSEA = 0.065, SRMR=0.031) of the proposed model, SEM reveals that (a) academic factors (i.e., educational aspiration in attaining educational degrees, the degree of taking advanced math courses, total number of AP/IB math courses, and educational levels of math teachers) have a significant direct effect on math achievement level, regardless of gender (p<. 001); (b) two sequential math self-efficacy latent variables are positively associated with math achievement (p<.001); (c) there are positive relationships among the academic factors and the math self-efficacy in 2002 (p<.001); (d) compared to male students, female students have significantly lower self-efficacy levels in both years, 2002 and 2004 (p<.001), which is most likely to affect lower math achievement (p<.001); (e) compared to male students, female students are more likely taking advanced math courses and aspiring to attain higher educational degrees (p<.001). Table 1 shows the detailed model results including standard errors and factor loadings of the variables. The Table 2 represents the total and indirect effects for the math achievement.

Table 1. Maximum Likelihood Robust Estimates Direct Effects of Math Achievement Model

	Estimate	S.E.	Est./SE	Std	StdYX
MEASUREMENT MODEL					
MSEFFI_1[1] BY					
MSE_11[2]	1.000	0.000	0.000	0.751	0.810
MSE_12[3]	1.022**	0.007	146.674	0.767	0.817
MSE_13[4]	1.102**	0.009	129.192	0.827	0.857
MSE_14[5]	1.077**	0.008	127.238	0.808	0.857
MSE_15[6]	1.075**	0.009	121.681	0.807	0.853
MSEFFI_2[7] BY					
MSE_21[8]	1.000	0.000	0.000	0.722	0.804
MSE_22[9]	1.022**	0.009	117.570	0.738	0.820
MSE_23[10]	1.045**	0.009	115.003	0.754	0.815
MSE_24[11]	0.942**	0.008	119.626	0.680	0.774
MSE_25[12]	1.041**	0.008	122.660	0.752	0.808
STRUCTUAL MODEL					
MSEFFI_2 ON					
MSEFFI_1	0.462**	0.008	55.618	0.480	0.480
MSEFFI_1 ON					
FEMALE	-0.211**	0.012	-17.493	-0.281	-0.141
SES	0.044**	0.005	8.079	0.058	0.066
Math Teacher Educational Level	0.012*	0.006	2.010	0.015	0.016
Educational	0.128**	0.004	29.342	0.171	0.246

1 Math Self-Efficacy in 2002
2 Can do excellent job on math tests
3 Can understand difficult math texts
4 Can understand difficult math classes
5 Can do excellent job on math assignment
6 Can master math class skills
7 Math Self-Efficacy in 2004 follow-up
8 Can do excellent job on math tests
9 Can understand difficult math texts
10 Can understand difficult math classes
11 Can do excellent job on math assignment
12 Can master math class skills

Aspiration					
MSEFFI_2 ON					
Female	-0.058**	0.011	-5.318	-0.080	-0.040
SES	0.013*	0.005	2.757	0.019	0.021
Math Teacher Educational Level	0.007	0.005	1.269	0.009	0.009
Educational Aspiration	0.022**	0.004	5.448	0.030	0.044
Math Standard Score ON					
MSEFFI_2	2.463**	0.096	25.617	1.778	0.192
MSEFFI_1	0.370**	0.093	3.977	0.277	0.030
Math Course Taking Pipeline ON					
MSEFFI_2	0.186**	0.020	9.523	0.134	0.082
MSEFFI_1	0.389**	0.019	20.431	0.292	0.178
Total AP/IB Math Courses ON					
MSEFFI_2	0.034**	0.005	6.387	0.025	0.063
MSEFFI_1	0.084**	0.005	16.068	0.063	0.162
Math Standard Score ON					
Math Course Taking Pipeline	2.366**	0.046	51.362	2.366	0.420
Total AP/IB Math Courses	3.591**	0.148	24.260	3.591	0.151
Math Teacher Educational Level	0.183*	0.053	3.428	0.183	0.020
Educational Aspiration	0.315**	0.045	6.942	0.315	0.049
SES	1.422**	0.052	27.395	1.422	0.175
Female	-1.292**	0.110	-11.767	-1.292	-0.070
Math Course Taking Pipeline ON					
Educational Aspiration	0.349**	0.009	40.872	0.349	0.306
Female	0.117**	0.022	5.266	0.117	0.036
SES	0.339**	0.010	33.180	0.339	0.235
Math Teacher Educational Level	0.063**	0.011	5.845	0.063	0.039
Total AP/IB Math Courses ON					
Educational Aspiration	0.031**	0.002	16.260	0.031	0.115
Female	0.000	0.006	-0.055	0.000	0.000
SES	0.044	0.003	16.109	0.044	0.127
Math Teacher Educational Level	0.019	0.003	6.509	0.019	0.049
Educational					

Aspiration ON					
Female	0.404	0.021	18.926	0.404	0.141
SES	0.369	0.009	39.068	0.369	0.292
Math Teacher Educational Level ON					
Female	-0.006	0.016	-0.375	-0.006	-0.003
SES	0.053**	0.007	7.464	0.053	0.059
Selected goodness-of-fit indices					
X^2 (df=92) = 6463.713, p<.000; CFI = 0.950; TLI =0.926; RMSEA = 0.065; SRMR = 0.031					

Table 2. Standardized Total and Indirect Effects for the Math Achievement Model

	Estimate	S.E.	Est./S.E.	Std	StdYX
Effects from MSEFFI_2 to Math standard score					
Total	3.026**	0.114	26.627	0.236	0.236
Total indirect	0.562**	0.058	9.655	0.044	0.044
Specific indirect					
Math standard score					
Math course taking pipeline					
MSEFFI_2	0.440**	0.047	9.393	0.034	0.034
Math standard score					
Total AP/IB Math Courses					
MSEFFI_2	0.123**	0.020	6.240	0.010	0.010
Direct					
Math standard score					
MSEFFI_2	2.463**	0.096	25.617	0.192	0.192
Effects from Math teacher educational level to MSEFFI_2					
Total	0.012*	0.006	2.079	0.017	0.017
Total indirect	0.005*	0.003	2.009	0.008	0.008
Specific indirect					
MSEFFI_2					
MSEFFI_1					
Math Teacher Educational Level	0.005*	0.003	2.009	0.008	0.008
Direct					
MSEFFI_2					
Math Teacher Educational Level	0.007	0.005	1.269	0.009	0.009
Effects from SES to MSEFFI_1					
Total	0.092**	0.005	17.244	0.122	0.139
Total indirect	0.048**	0.002	23.831	0.064	0.073
Specific indirect					
MSEFFI_1					
Educational aspiration					
SES	0.047**	0.002	23.775	0.063	0.072
MSEFFI_1					
Math Teacher Educational Level					
SES	0.001	0.000	1.935	0.001	0.001
Direct					
MSEFFI_1					
SES	0.044**	0.005	8.079	0.058	0.066
Effects from Female to MSEFFI_1					
Total	-0.159**	0.012	-13.017	-0.212	-0.106
Total Indirect	0.052	0.003	15.709	0.069	0.035

DISCUSSION AND CONCLUSION

The results show that, for female students, among the antecedent learning factors, math self-efficacy has most significant effect on the math standard score. Interestingly, although female students have better math educational preparation in terms of taking advanced math courses and have higher educational aspiration than male students, they have lower math achievement than male students. Importantly, unlike the other learning factors, female students have significantly lower math self-efficacy than male students. It is most likely that the major learning factor impacting on lower math achievement of female students is the math self-efficacy of the female students. In fact, regardless of gender, SES, GPA, taking advanced math courses and higher educational aspiration significantly impact on math standard scores. These findings suggest that how to increase math self-efficacy is a critical matter for female students to improve math standard scores.

Considering the importance of math self-efficacy for female students, teachers, counselors, and parents should be aware of how educational environments and learning processes can increase the math self-efficacy of female students. Future studies should investigate the sources of math self-efficacy, gender differences in the sources, and the extent to which the sources impact on math self-efficacy and math achievement levels, conceptually framing the hypothesized sources of self-efficacy (i.e., experienced mastery, vicarious experience, verbal and social persuasions, and emotional and physical states) by Bandura (1986, 1997).

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