

## Moderated Mediation Effects of Self-Efficacy on Metacognition and Mathematics Achievement of College Students

Arnel Arcenal, Jolly Balila, Vicky Mergal,  
Gracel Ann Saban, Jezamine De Leon, Flor Villa Marticio

### Abstract

This study aimed to investigate the mediating effects of math self-efficacy on metacognition and math achievement among college students in five sectarian schools in the Philippines. It also aimed to investigate the moderating effects of gender, age, type of high school, and course on the mediational role of math self-efficacy. The study involved 203 College Algebra students as respondents. Non-experimental quantitative technique was used in exploring the relationships among variables. Particularly, a path analysis employing a model-fitting approach through the software IBM SPSS Amos 18 was used in the moderated mediation analysis. Using the Metacognitive Awareness Inventory-Abridged (MAI-A) to measure metacognition, Math Self-Efficacy Scale (MSES) to measure self-efficacy, and the College Algebra Test to measure mathematics achievement, it was found that metacognition significantly and positively affected both math self-efficacy and math achievement. The mediation analysis revealed that math self-efficacy fully mediated the effect of metacognition on math achievement. Among the four moderators (i. e., gender, age, type of high school graduated from, and course) only course taken by the students showed a significant moderating effect on the mediational role of math self-efficacy on metacognition and math achievement. Overall, this study constructed and tested 10 models and was able to establish eight.

*Keywords: metacognition, math self-efficacy, math-achievement, mediation, moderated mediation.*

Mathematics plays a very important role in daily living. It helps people understand many phenomena taking place around them. In many ways, it touches the lives of great men, as well as of ordinary people. In this era of high advancement, mathematics is the backbone of science and technology, business and economics, engineering, computing, telecommunications, and many other fields. Today's fast-advancing world makes mathematics a real must. With this great importance, it is but proper that mathematics teaching and learning be given due attention locally and globally by researchers and educators.

It is worth noting that there is an international research agency the so-called International Association for the Evaluation of Educa-

tional Achievement (IEA) that conducts periodic evaluation on mathematics performance of the different countries around the world through the Trends in Mathematics and Science Study (TIMSS). The TIMSS results in 1995, 1999, 2003, 2008, and 2011, however, showed that students from many countries are not doing well in mathematics (Mullis, Martin, Foy, & Arora, 2012; Mullis, Martin, Robitaille, & Foy, 2009).

In the Philippines, results of the National Achievement Test (NAT) in Mathematics showed that fourth year students obtained low mean percentage scores: 50.70 % in school year (SY) 2004–2005; 47.82% in SY 2005–2006; and 46.37% in SY 2011–2012 (Department of Education National Testing Center, 2012). This dismal perfor-

mance in mathematics of Filipino high school students in the TIMSS and NAT has alarmed the Philippine Congressional Commission on Science and Technology and Engineering (Flejoles & Depamayo, 2011). Along this vein, Van der Walt and Maree (2007) say that “facilitating mathematics learning is a cause of concern to countries throughout the world” (p. 233).

In view of the foregoing reality, educational psychologists and researchers have been spending much time and effort in exploring factors that would enhance students’ learning and performance in mathematics. For several decades now, researchers have particularly investigated the great potential of metacognition (Efklides, 2009; Pihlainen-Bednarik & Keinonen, 2011; Shwartz & Perfect, 2002) and self-efficacy (Bandura, 2006; Siegel & McCoach, 2007; Vuong, Brown-Welty, & Tracz, 2010) as separate predictors of academic performance. Metacognition refers to students’ awareness of their own thinking and their ability to regulate thinking and learning processes (Akturk & Sahin, 2011; Baumeister & Bushman, 2014). On the other hand, self-efficacy refers to a person’s beliefs on being able to successfully accomplish certain tasks (Dunn & Craig, 2013; Santrock, 2011).

Considering the difficulties encountered by students in learning mathematics and the promising potentials of metacognition and self-efficacy, it is, therefore, the intent of this study to provide insights into the effects of college students’ metacognitive ability to their achievement in mathematics with their mathematics self-efficacy as a mediating factor.

### Statement of the Problem

This study aimed to establish models on the mediating effects of self-efficacy on metacognition and mathematics achievement among college students in five sectarian schools in the Philippines. Further, it investigated the moderating effects of gender, age, type of high school graduated from, and course enrolled by the students on the mediational model.

Specifically, this study aimed to answer the following research questions:

1. Does metacognition significantly affect mathematics achievement?
2. Does metacognition significantly affect mathematics self-efficacy?
3. Does mathematics self-efficacy significantly affect mathematics achievement?
4. Does mathematics self-efficacy significantly mediate between metacognition and mathematics achievement?
5. Do age, gender, type of high school the students graduated from, and course enrolled each moderate the mediating effect of mathematics self-efficacy?

### METHODS

This study used non-experimental quantitative technique in exploring the relationships among variables. Particularly, a moderated mediation path analysis employing a model-fitting approach was used. The research instrument used in this study consisted of three questionnaires: the Metacognitive Awareness Inventory–Abridged (MAI-A), the Mathematics Self-Efficacy Scale (MSES), and the College Algebra Test (CAT). The MAI-A consisted of 32 items that were lifted from the 52-item Metacognitive Awareness Inventory (MAI) developed by Schraw and Dennison. The MSES and the CAT were both constructed by the researcher. The questionnaires were constructed validated and the internal consistency were established with Cronbach alpha reliability of greater than 0.60.

### RESULTS

IBM SPSS for Windows 7 and Amos 18 outputs showed causal relationships among the variables under study. It was found that metacognition significantly and positively affected math achievement ( $\beta=.174, p<.05$ ). Similarly, metacognition significantly and positively predicted math self-efficacy (path coefficient=.402,  $p<.001$ ) and math-self efficacy also significantly and positively affected math achievement (path coefficient=.394,  $p<.001$ ). The mediation analysis revealed that math self-efficacy fully mediated the effect of metacognition on math achievement (i. e., mediating effect coefficient=.161,  $p=.001$ ).

The moderating effects of gender, type of high school students graduated from, and course taken by the students were assessed through model comparison or model invariance analysis. IBM SPSS Amos 18 generated model fit measures for model comparison analysis. It was found that gender did not have a significant moderating effect on the mediational role of math self-efficacy on metacognition and math achievement ( $CMIN = .044$ ,  $df=2$ ,  $p=.978$ ). Path analytic regression analysis also through IBM SPSS Amos 18 was used to examine the moderating effect of age. It was found that age of the respondents also did not have a significant moderating effect on the mediational role of math self-efficacy (path coefficient=.060,  $p=.339$ ). Model comparison analysis revealed that the type of high school students graduated from also did not have a significant moderating effect on the mediational role of math self-efficacy on metacognition and math achievement ( $CMIN= 2.330$ ,  $df=2$ ,  $p=.312$ ).

The model comparison analysis for course as a moderator revealed that course taken by the students when grouped according to math-related courses, health-related courses, and nonmath-nonhealth-related courses exhibited a significant moderating effect on the mediational role of math self-efficacy on metacognition and math achievement ( $CMIN=11.226$ ,  $df=2$ ,  $p=.024$ ). A pairwise comparison analysis on the

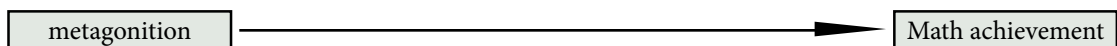
three groups of courses taken by the students was done to examine the moderating effect of course. In comparing the mediation models for math-related courses and health-related courses, it was found that there was no significant difference between the two models ( $CMIN=.241$ ,  $p=.887$ ). In comparing the mediation models for math-related courses and nonmath-nonhealth related courses, a significant difference was found ( $CMIN=8.165$ ,  $df=2$ ,  $p=.017$ ). Likewise, a significant difference was found between the mediation models for health-related courses and non-math-nonhealth-relatedcourses ( $CMIN=6.267$ ,  $p=.044$ ).

Overall, this study constructed and tested 10 models and was able to establish eight.

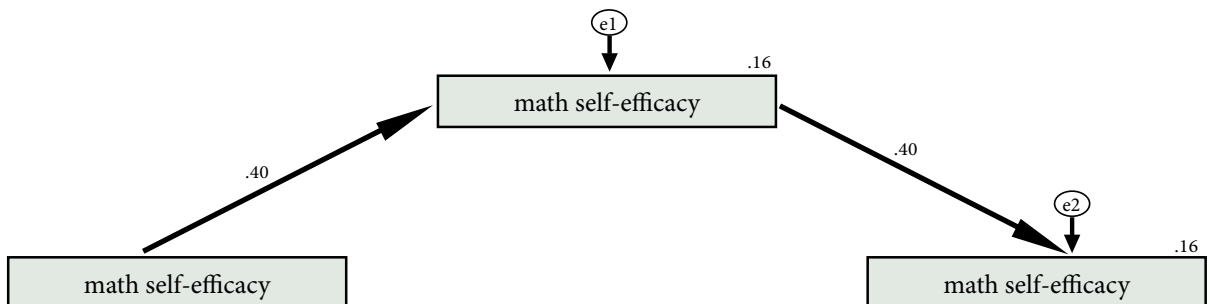
Model 1 shows that in isolation, metacognition significantly and positively affected math achievement ( $\beta=.174$ ,  $p<.05$ ).

Model 2 shows the following relationships – (1) metacognition significantly and positively affected math self-efficacy (path coefficient=.402,  $p<.001$ ); (2) math self-efficacy significantly and positively affected math achievement (path coefficient=.394,  $p<.001$ ); (3) metacognition did not directly affect math achievement; and (4) math self-efficacy fully mediated the effect of metacognition on math achievement (mediating effect coefficient=.161,  $p=.001$ ) of students.

Model 1. Metacognition - Math Achievement Unmediated Model



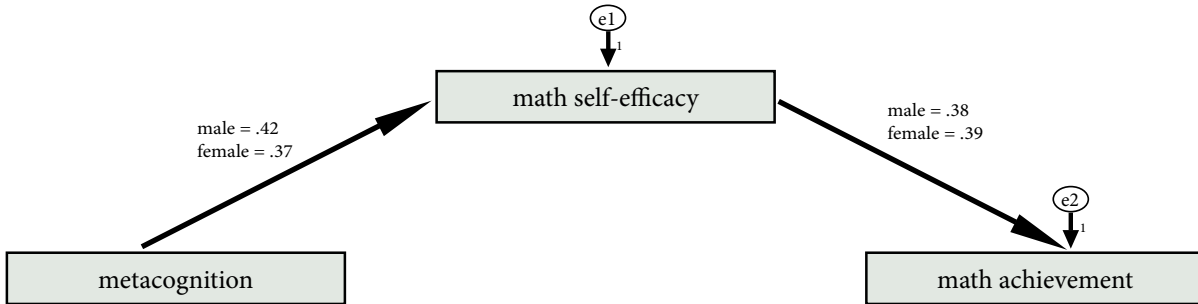
Model 2. Metacognition – Math Self-Efficacy – Math Achievement Mediation Model



$CMIN=.049$ ,  $DF=1$ ;  $p=.824$ ;  $RMSEA=.000$ ;  $NFI=.999$ ;  $CFI=1.000$

Model 3 shows that gender did not significantly moderate the mediating effect of math self-efficacy on metacognition and math achievement ( $CMIN=.044, p=.978$ ).

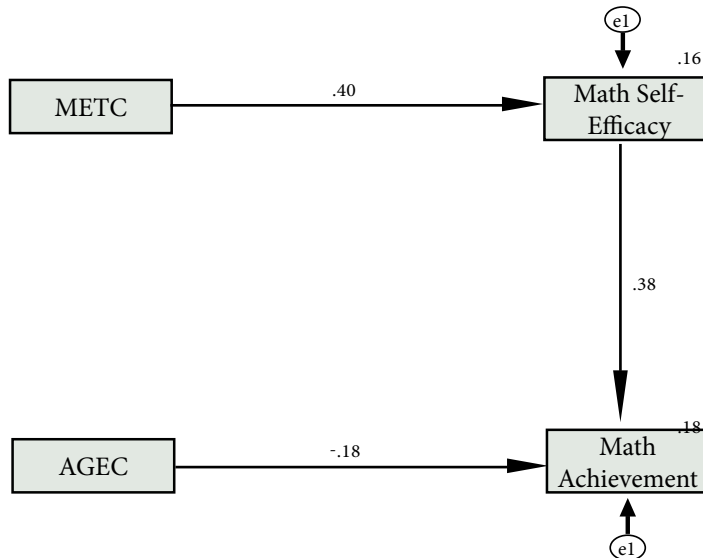
Model 3. Gender-Moderated Metacognition – Math Self-Efficacy – Math Achievement Mediation Model



Structural Weights Comparison:  $CMIN=.044, DF=2, p=.978$

Model 4 reveals that age did not moderate the mediating effect of math self-efficacy on metacognition and math achievement of students. The model, however, reveals that age significantly and negatively affected math achievement (path coefficient =  $-.18, p<.001$ ).

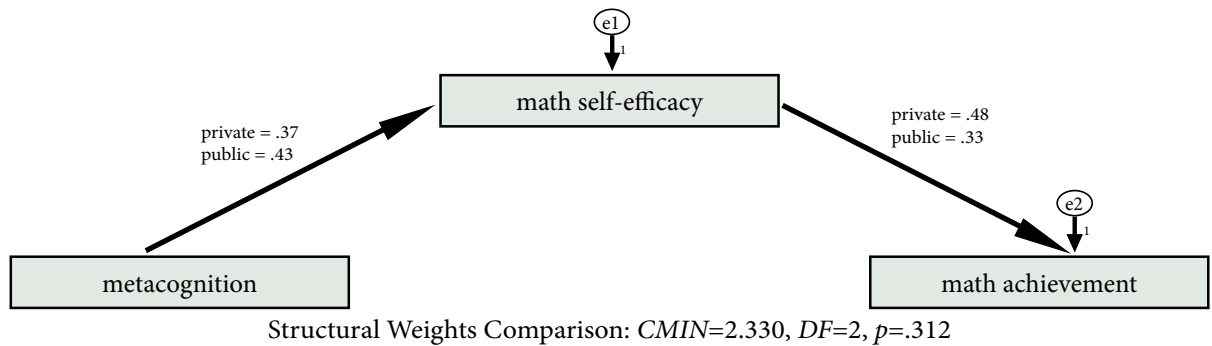
Model 4. Age-Related Metacognition – Math Self-Efficacy – Math Achievement Mediation Model



$CMIN=3.695, DF=3, p=.296; RMSEA=.034; SRMR=.0478; NFI=.955; CFI=.991; GFI=\backslash GFI$

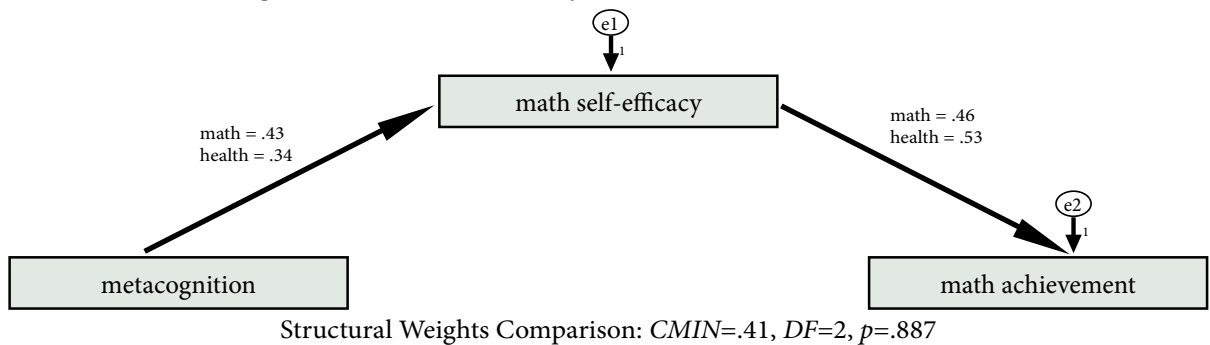
Model 5 discloses that the type of high school students graduated from did not significantly moderate the mediating effect of math self-efficacy on metacognition and math achievement.

Model 5. Type of High School-Moderated Metacognition – Math Self-Efficacy – Math Achievement Mediation Model



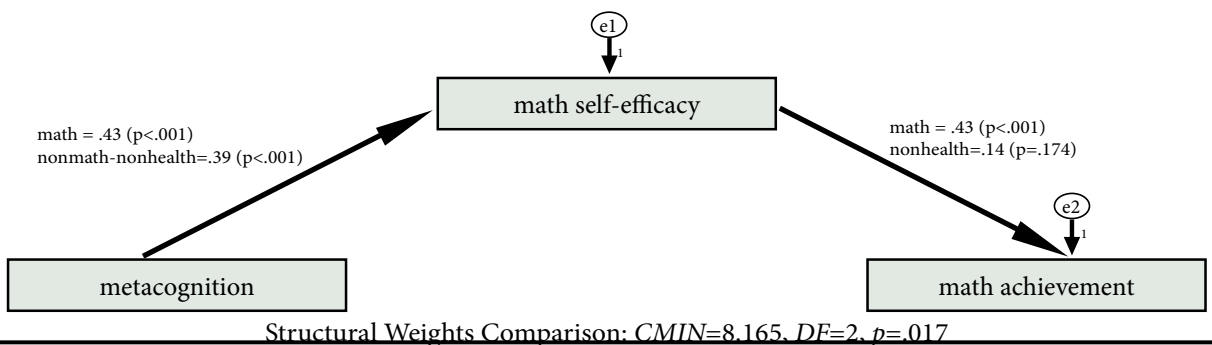
Model 6 reveals that course when grouped according to math-related courses and health-related courses only did not moderate the mediating effect of math self-efficacy on metacognition and math achievement.

Model 6. Math-Related Course vs Health-Related Course-Moderated Metacognition – Math Self-Efficacy – Math Achievement Mediation Model



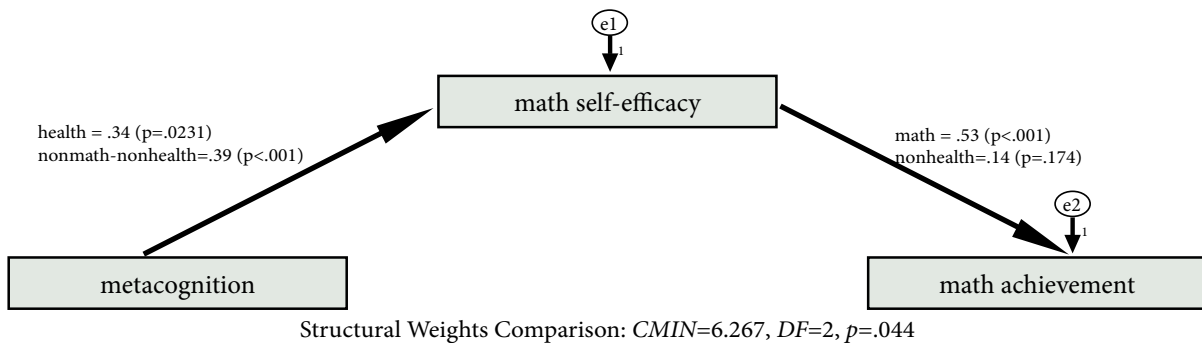
Model 7 shows that course when grouped according to math-related courses and non-math-nonhealth-related courses only significantly moderated the mediating effect of math self-efficacy on metacognition and math achievement. For students taking math-related courses, metacognition significantly affected math self-efficacy ( $p<.001$ ) which in turn significantly affected math achievement ( $p<.001$ ); whereas, for students taking nonmath-nonhealth related courses, metacognition significantly affected math self-efficacy ( $p<.001$ ) but math self-efficacy did not significantly affect math achievement.

Model 7. Math-Related Course vs Nonmath-nonhealth-Related Course-Moderated Metacognition – Math Self-Efficacy – Math Achievement Mediation Model



Model 8 shows that course when grouped according to health-related courses and non-math-nonhealth-related courses only significantly moderated the mediating effect of math self-efficacy on metacognition and math achievement. For students taking health-related courses, metacognition significantly affected math self-efficacy ( $p=.023$ ) which in turn significantly affected math achievement ( $p<.001$ ); whereas, for students taking nonmath-nonhealth related courses, metacognition significantly affected math self-efficacy ( $p<.001$ ) but math self-efficacy did not significantly affect math achievement ( $p=.174$ ).

Model 8. Health-Related Course vs Nonmath-nonhealth-Related Course-Moderated Metacognition – Math Self-Efficacy – Math Achievement Mediation Model



## DISCUSSION

The study showed that College Algebra students in the five sectarian schools in the Philippines who have higher metacognitive ability achieve better in mathematics than those who are less metacognitive. This supports previous studies (Ozsoy, 2011; Topcu & Yilmaz-Tuzon, 2009; Young & Fry, 2008; ) which showed that metacognition is a predictor of academic achievement. The study also showed that those who are more metacognitive have higher math self-efficacy, that is, they perceive themselves to be highly capable of doing mathematical tasks. This is also in consonance with the findings of Al-Harthi (2010) and Coutinhu (2008) which revealed a significant positive relationship between metacognition and self-efficacy.

Furthermore, the study also showed that those students who perceive themselves to be highly capable of performing mathematical tasks achieve better in mathematics than those who perceive themselves to be less capable. It is interesting to note from Model 2 that mathematics self-efficacy fully mediates the effect of metacognition on math achievement. This goes to show that the effect of metacognition on math achievement is completely coursed through math self-efficacy.

Among the four moderators considered (i. e., gender, age, type of high school graduated from, and course), only course taken by the students showed a significant moderating effect on the mediational role of math self-efficacy on metacognition and math achievement. This implies that the degree of the mediational role of math self-efficacy differs according to course groupings. In this study, the courses were categorized into math-related, health-related, and non-math-non-health-related.

Table 1 shows that among the three course categories, the mediating effect of math self-efficacy is highest on students taking a math-related course. This, however, is not significantly different from those taking a health-related course. Clearly, the mediating effect of math self-efficacy is lowest on those taking a non-math-non-health-related course and is significantly different from the two other course groups.

Table 1  
Pairwise Chi-Square (CMIN) Analysis (DF=2) of the Three Course-Moderated Mediation Models

	Math-related	Health	Indirect or Mediating Effect
Math-related			.196 ( $p=.001$ , significant)
Health-related	CMIN=.241 ( $p=.887$ , not significant)		.180 ( $p=.015$ , significant)
Nonmath/Nonhealth	CMIN=8.165 ( $p=.017$ , significant)	CMIN=6.267 ( $p=.044$ , significant)	.055 ( $p=.171$ , not significant)

## CONCLUSION

Based on the findings, it can be concluded that metacognition was significantly and positively affected by math self-efficacy and math achievement. Students who perceived themselves to be highly capable of doing mathematical tasks had difficulty performing such tasks. The strong belief of students in performing mathematical task yields better achievement in mathematics.

Among students who are taking non-math-related courses, although with a higher level of awareness and regulation of learning processes and have a stronger belief in their capability to perform mathematics, math achievement is practically the same for male and female students. Moreover, having all factors constant, students' beliefs on their capability to do mathematical tasks mediate their awareness and regulation of learning processes.

The mediation analysis revealed that math self-efficacy fully mediated the effect of metacognition on math achievement. Among the four moderators (i. e., gender, age, type of high school graduated from, and course) the only course taken by the students showed a significant moderating effect on the mediational role of math self-efficacy on metacognition and math achievement. This study was able to establish eight models based on the 10 constructed and tested models.

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