Self-Efficacy and Performance in Mathematics of Science High School Students

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It is assumed that being in a competitive science high school (SHS) affects the students' mathematics self-efficacy (MSE) or their belief that they can succeed in Mathematics. Low MSE may result in poor mathematics performance (MP) and may lead to students' underperformance. This study aimed to identify which sources of MSE contributed to the MSE of 144 Grade 11 SHS students in the Philippines and if there was a significant relationship between MSE and MP, and if the former could predict the latter.

A mixed-method approach was adopted using statistical analysis by PLS-PM and thematic analysis of semi-structured interviews with 23 students. Findings showed that mastery and vicarious experiences influenced the SHS students' MSE but there was no significant relationship between MSE and MP. Mastery experiences (ME) and efforts in learning math skills, not just MSE, were strong predictors of MP.

It is recommended that teachers become aware of the students' efficacy threshold to experience mastery through increasing difficulty. Collaborative learning is essential to lessen negative vicarious experiences.

Keywords: *mathematics self-efficacy, sources of mathematics self-efficacy, mathematics performance, Science high school students*

Introduction

In order to successfully excel in Mathematics, students need to overcome difficulties related to tasks and activities in the curricula. This is referred to as the Mathematics Self-Efficacy (MSE) (Carpenter & Clayton, 2014). MSE is also the extent to which students believe in their ability to handle mathematical tasks effectively and overcome difficulties in performing the assigned tasks (OECD, 2013). It originated from Bandura's (1997) Social Cognitive Theory, in which self-efficacy affects adaptation to changes and impacts the personal, behavioral, and environmental determinants (Bandura, 1989, 1994, 1997).

In the science high school (SHS) where the study was conducted, it was found that from 2013 to 2018, out of the original roster of 240 students accepted in Grade 7, 13 were dismissed because of failing marks in Mathematics. Out of 114 participants in the present study, 13 students had a grade of 2.5 or below (using a 5-point grade system with 1.0 as the highest grade), which is low for students who supposedly excel in STEM and have passed the competitive entrance exam for SHS. Thus, it is important to understand the factors that may affect the SHS students' MP to keep their interest in Math and STEM in general.

Based on the researchers' observations, the students' self-efficacy particularly in Mathematics was deemed a crucial factor that affected their performance in the subject. Studies show that self-efficacy significantly contributes to the individual's level of motivation and performance (Collins, 1982, as cited in Bandura, 1992). Individuals with higher self-efficacy set higher goals for themselves and commit to achieving them (Wood & Bandura, 1989; Taylor et al., 1984, as cited in Bandura, 1992; Locke et al., 1984), so self-efficacy plays an important role in regulating causal attributions, outcome expectations, and cognized goals (Relich et al., 1986, as cited in Bandura, 1992).

This research used Bandura's theory of self-efficacy as its theoretical framework. According to Bandura (1997), perceived self-efficacy is formed through the interpretation of information from four sources. The first source, mastery experiences (ME), refers to the interpretation of previous experiences and performances in accomplishing specific mathematics tasks, and whether they increase (success) or decrease (failure) the individual's MSE level (Bandura, 1997; Pajares, 2001; Usher & Pajares, 2009). The second source is vicarious experiences (VE) or the effects of modeling from peers, teachers, or adults. A model's successful performance of mathematics skills and perceived similarity with the model can increase the individual's MSE level (Bandura, 1997; Schunk & Usher, 2013; Zimmerman, 2013). Social persuasion (SP), the third source, refers to the feedback from peers, teachers, or adults. Timely and realistic feedback and encouragement from peers or adults can also influence the individual's MSE level (Bandura, 1995, 1997). The fourth source is the physiological and emotional states (PES), which refer to the individual's interpretation of physical and emotional manifestations of their attitude towards performing mathematics activities.
A positive interpretation increases MSE (Bandura, 1992, 1997, 1999; Chen & Usher, 2013).

If the individual has positive mathematics experiences, an effective teacher-model who is an expert in the field, effective feedback mechanisms, and positive interpretations of physical and emotional situations, the expected MSE level is high. However, the lack or opposite of these experiences may lead to a lower MSE level. Most of the studies, including cross-cultural studies, support the claim that of the four sources of MSE, ME is the most powerful one (Arslan, 2012, 2013; Bandura, 1997; Britner & Pajares, 2006; Chen & Usher, 2013; Kesan & Kaya, 2018; Lent et al., 1996; Lopez & Lent, 1992; Usher & Pajares, 2009; Yurt, 2014).
This means that the interpretations of success and failure in performing a specific mathematics task affect the individual's MSE level. It also shows that individuals value their learning, performance, abilities, development of skills, and the efforts they put in their performance to feel more or less efficacious. Moreover, to increase the individual's MSE level, the learning environment should provide successful experiences that meet the individual's abilities while retaining the novelty and challenging aspects of the learning experience.

MSE has a direct relationship with MP and is a strong predictor of academic achievement across domains and age levels (Britner & Pajares, 2006; Schunk & Pajares, 2005, as cited in Chen & Usher, 2013). Studies on high school students reveal a positive relationship between MSE and MP in geometry and algebra classes (Ayotola & Adedeji, 2009; Lent et al., 1996; Pajares & Graham, 1999). They also show how MSE predicts the problem-solving performance of gifted students in middle school algebra after controlling for anxiety, ability level, and Math grades (Pajares, 1996). The results indicate that students who are confident in their ability to perform well on Math tests performed better.

On the other hand, cross-cultural studies show that Asians' MSE has an indirect relationship with MP, as Asian students have high MP despite their low MSE level. Researchers attribute this different result to other factors that predict mathematics performance and achievement such as fear (Eaton & Dembo, 1997); modesty and self-criticism (Mau, 2000); family-oriented goal (Salili et al., 2001); and "*hiya*" (shame) (Causapin, 2016).

In the Philippines, different studies on MSE and MP have been conducted covering factors and interventions that affect the development of MSE (Domocmat, 2010; Encarnacion, 2010; Joaquin, 2007; Velasco, 2013). Dullas (2010) finds a significant relationship between science high school students' self-efficacy and academic achievement in Math and possessing a high level of self-efficacy. So, this present study aims to contribute to scant research that focuses on the factors that affect the SHS students' MP, as math ability is one of the critical skills in choosing a career in STEM and that MSE is one of the factors that affect MP. Understanding these factors will help in developing the students' interest in Math, Science, Technology, and Engineering. Science high schools, being the vital pipeline of STEM professionals in the country, aim to contribute to nation-building and development. Thus, a study conducted in a science high school also aims to contribute to research that focuses on the vital role of STEM.

Purpose of the Study

This study investigated the sources of mathematics self-efficacy (MSE) of science high school students and whether MSE as the independent variable affects the students' mathematics performance. This study focused on the following questions:

1. Which among the sources of the Mathematics Self-Efficacy, namely mastery experiences, vicarious experiences, social persuasions, and physiological and emotional states contribute to the development of MSE?
2. Is there a significant relationship between
   a. sources of mathematics self-efficacy and mathematics self-efficacy?
   b. Mathematics self-efficacy and students' mathematics performance?
3. Can the MSE of science high school students predict their MP?

Methodology

The mixed-method research design used in the study is Concurrent Triangulation Strategy. The researcher collected both quantitative and qualitative data in parallel and then compared the results to determine if there was confirmation, disconfirmation, cross-validation, or corroboration (Greence et al., 1989, as cited in Creswell, 2014). The steps done were as follows:

1) Permissions were secured from the school;

2) The instruments were pilot-tested on three different campuses;

3) Parents' consent was sought;

4) After filling out the demographic profile, the participants of the study answered the Sources of Mathematics Self-Efficacy Scale (SMSES) and Mathematics Self-Efficacy Scale (MSES) in coordination with the subject teachers;

5) The data on the Mathematics performance was provided by the Registrar's Office of the science high school;

6) 30 students were invited for interviews to represent at least 20% of the total number of participants, but some interviewees did not show up and some were not interviewed due to mental health concerns. Thus, only 23 students were interviewed;

7) The interviews lasted from 30 minutes to one hour, averaging about 40 minutes. After all the data were collected, a thematic analysis of the semi-structured interviews with 23 students followed.

Sources of Mathematics Self-Efficacy Scale (SMSES)

The first rating scale used is the Sources of Mathematics Self-Efficacy Scale (SMSES) which was adopted from Usher & Pajares (2009). The SMSES assesses the four sources of self-efficacy namely, mastery experience (ME), vicarious experience (VE), social persuasion (SP), and physiological and emotional states (PES). Then the researcher contextualized some situations to make them more applicable to the Philippine setting. SMSES comprised 24 items to be rated on a 6-point Likert scale. The 24 items were equally divided to correspond to each source of MSE, such that items 1 to 6 corresponded to ME; items 7 to 12 corresponded to VE; items 13 to 18 corresponded to SP; and items 19-24 corresponded to PES.

Mathematics Self-Efficacy Scales (MSES)

The second rating scale, Mathematics Self-Efficacy Scales (MSES), is developed by Hackett (1985). It is a 68-item measure of a student's beliefs regarding their ability to perform various math-related tasks and behaviors, which is based on Bandura's (1997) measure of self-efficacy. Each item is rated on a 9-point Likert scale and composed of three parts: Everyday Math Tasks, Math Applications, and Mathematics Courses.

Everyday Math Tasks consists of 18 statements aimed to measure the mathematics behaviors used in everyday life, such as, "*Balance your stipend in your bank account without a mistake*." It also involves solving math problems applied in different subjects, such as, "Figure *out how long it will take to travel from your house to your campus at 80 kph.*"

Math Proving Domain (MPD) applications on differential and integral mathematics is a researcher-developed mathematics test and was tested for validity and reliability. It is composed of 30-item mathematics equations and problems to be rated by the student according to their confidence in successfully getting the correct answer. An example of the mathematics problem statement is, "*How much confidence do you have that you could successfully answer the following mathematics problems correctly: Compute for the degree measure of an arc intercepted by a central angle of measure 50 degrees*."

Mathematics Courses is composed of 20 mathematics-related courses developed by Hackett (1985). In this test, the students were asked to rate their confidence in completing the course with a final grade of "1.0" to "1.5."

A total of 144 students were surveyed, and the researcher adopted Ashcraft and Moore's (2009) statistical cutoffs based on the mean and standard deviation to categorize students into three levels. The mean of all the participants was 5.41, with a standard deviation of 1.46. The students who had MSE mean scores which were 1 SD above the mean (6.86 and above) were categorized as with high MSE (HMSE); those who scored 1 SD below the mean (3.95 and below) were categorized as with low MSE (LMSE); and for those average MSE (AMSE), their score ranged from plus or minus 0.5 SD from mean (4.68 to 5.64). Out of 144 students, 45 students were invited to represent each level of MSE—15 each level—but only 23 students responded. Out of the 23, 11 had HMSE, 6 had AMSE, and 6 had LMSE.

Mathematics Performance

Mathematics Performance is the numerical Mathematics general weighted average (GWA) received by the student at the end of the school year. In this study, the science high school used a 5-point grade system in which 1.0 was the highest, 2.5 and 2.75 were considered substandard grades, 3.0 was the passing rate, 4.0 was the conditional grade, and 5.0 was the failing mark.

Semi-Structured Interview

A semi-structured interview was conducted to collect qualitative data. The Qualitative Student Interview Protocol was adopted from Usher (2009) and contextualized to the Philippine setting. It was composed of 42 open and closed-ended questions and was divided into six parts. Part 1 explored the person-input and distal contextual background of the students. This was further divided into subcategories such as family background, socio-economic status, and educational background of parents, siblings, and the student. Parts 2 to 5 explored each source of MSE, namely, ME, VE, SP, and PES. The last part explored the SHS students' interests and career-choice in STEM. After initial data analysis, follow-up questions were asked for clarification of meaning, elaborations, and concrete examples. The interview was conducted in mixed Filipino-English for ease of conversation.
All interviews were audio-recorded and transcribed verbatim.

Some sample interview questions include: 1) If you were asked to rate your ability in Math on a scale of 1 (lowest) to 10 (highest), where would you be? Why?; 2) With the upcoming UPCAT, how would you rate your confidence that you will do well on the Math part of the test?; 3) Share with me a time you experienced a setback in Math. How did you deal with it?; 4) How would you say you compare in math abilities, to the rest of your classmates? To the whole batch?; 5) Does your grade affect your confidence in Mathematics and taking Mathematics courses? Explain.

Data Analysis

The quantitative data collected from the two instruments and the Mathematics GWA were analyzed and interpreted using the Partial Least Squares – Path Modeling (PLS-PM) with R. On the other hand, the qualitative data were transcribed, coded, and analyzed manually. They were analyzed using both inductive and deductive analyses. At first coding, patterns and themes were established through inductive analysis. During the interviews, some of the students got comfortable in sharing that some of their answers already addressed several constructs. This led to multiple codes, prompting the researcher to review the individual transcripts and codes to combine similar codes as they repeatedly appear. Magnitude coding (Saldaña, 2009) was used to indicate the degree of contribution of each source to mathematics self-efficacy and the different factors that affected vocational interests and career choice in STEM, as shown in Table 1.

Table 1

Definition of Magnitude Codes for Sources of Mathematics Self-Efficacy

Codes	Definition
Positive	Participant's response contributed to high MSE level
Negative	Participant's response contributed to low MSE level
Neutral	Participant's response was inconclusive or no clear category as it increases or decreases MSE level.
Mixed	Participant's responses included contradictions.

Results and Discussion

The study aimed to investigate the sources of mathematics self-efficacy (MSE) of science high school (SHS) students and whether MSE as the independent variable affected the students' mathematics performance. It also sought to find out if there was a significant relationship between the students' MSE and mathematics performance (MP).

Assessment of the Measurement Model

Before the discussion of the results for each problem statement, the unidimensionality of the measurement model was tested to show that the latent variables (LVs)—sources of MSE, MSE, and MP—were measured by the statements in the instruments used. Table 2 shows the result of the three tests of unidimensionality. First, the Cronbach's alpha of each of the six items per source of MSE is greater than .70. This means that the statement "*I make excellent grades on Math tests*" measures the ME of the SHS students; "*I compete with myself in math*" measures VE; "*People have told me that I have a talent for math*" measures SP; and "*Doing math work takes all of my energy*" measures PES. The SHS students' MSE is measured by daily math application items such as, "*Determine the amount of sales tax on a food purchase*." MSE is measured by the SHS students' perception that they can successfully perform mathematics in daily tasks such as "*Computing the distance between their residence and school*." Lastly, this reveals that the Mathematics GWA measured the MP.

Table 2

Test for Unidimensionality of the Measurement Model

Latent variables (LVs)	Manifest variables (MVs)	C.alpha	DG.rho	eig.1st	eig.2nd
Mastery Experience	6	0.9048	0.9276	4.0991	0.6312
Vicarious Experience	6	0.8199	0.8699	3.1719	1.0808
Social Persuasion	6	0.9372	0.9506	4.5764	0.6474
Physiological and Emotional States	6	0.9118	0.9318	4.1724	0.6173
Mathematical Self-Efficacy	3	0.8028	0.8839	2.1518	0.4541
Mathematics Performance	1	1	1	1	0

Second is the Dillon-Goldstein rho (DG.rho) which is greater than .70, which means that the SHS students' MSE show that they are confident to successfully balance their stipend in their bank account without mistake, successfully solve math problems, and achieve a high grade in a mathematics course.

The last test is the eigenvalues of each latent variable which shows that the 1st eigenvalues for each latent variable are all greater than 1 (i.e., the acceptable value), and the 2nd eigenvalues are less than 1 for the latent variables, except for vicarious experience. This means that items 1-6 of the SMSES solely measured the ME and not the other sources which hold true for items that correspond to SP, PES, MSE, and MP. However, this is not true for vicarious experience as its 2nd eigenvalue is greater than one, which means that it has indicators that measure other variables. The convergent validity test shows that the students' agreement or disagreement with the VE item#7 and VE item #9 statements "*Seeing adults do well in Math pushes me to do better*" and "*Seeing kids do better than me in Math pushes me to do better*" is not explained by their vicarious experience. This further implies that the SHS students may not directly attribute age to good performance in specific mathematics tasks.

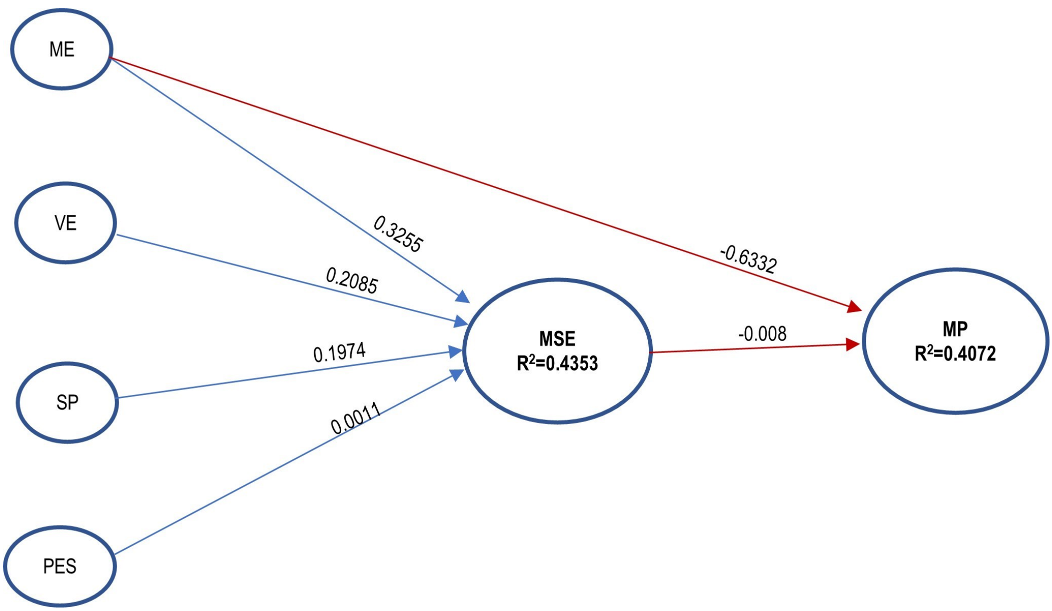
Sources of Mathematics Self-Efficacy

After establishing the unidimensionality of the measurement model, this study wanted to find out which among the four sources of MSE contributed the most to the development of the SHS students' MSE. As shown in Figure 1, the R^2 coefficient of MSE is at a moderate value of .4354, which means that

43.53% of the SHS students' MSE can be attributed to the four sources with mastery experiences (ME) as the primary source at .3255, followed by vicarious experiences (VE) at .2085, social persuasion (SP) at .1974, and physiological and emotional States (PES) at .0011. Among the four sources of MSE, the SHS students' mastery experiences or experience of success in performing mathematics tasks is the top predictor (0.3225) of MSE. While mastery experience is the top predictor, the score (0.3225) only indicates that mastery experiences may contribute moderately to mathematics self-efficacy. The three other sources, namely, VE, SP, and PES are less likely to explain the SHS students' MSE.

Figure 1

Structural (Inner) Model of PLS-PM with R for Sources of MSE, MSE, and MP



Shown in Table 3 is the summary of patterns of the magnitude of the SHS students' interpretations of their sources of MSE.

Table 3

Summary of the Sources of Mathematical Self-Efficacy's Magnitude Codes

Sources of MSE	Senior High School Students' Group		
	High MSE	Average MSE	Low MSE
ME	Mixed	Mixed to Negative	Mixed to Negative
VE from teachers	Neutral to Positive	Mixed	Mixed
VE from parents	Neutral	Neutral	Neutral
VE from peers	Mixed	Mixed	Mixed
SP from teachers	Neutral to Positive	Mixed	Mixed
SP from parents	Neutral to Positive	Mixed	Mixed
SP from peers	Mixed	Mixed	Mixed
PES	Positive	Mixed	Mixed

Note: Positive: Participants' response contributed to high MSE level
Negative: Participants' response contributed to low MSE level
Neutral: Participants' response was inconclusive or no clear category as it increases or decreases MSE level
Mixed: Participants' responses included both positive and negative.

Mastery Experiences

For the mastery experience, almost all the SHS students with high MSE levels showed positive interpretations of their mastery experiences as they interpreted their successes and failures positively. They sought challenging mathematics tasks to increase their mastery, which contributed to their self-efficacy. One SHS student with a high MSE level mentioned that he already reached his self-efficacy threshold in mathematics, thus he diverted his interest to learning Physics.

The SHS students with average and low MSE levels showed a mix of positive and negative interpretations of their mastery experiences. Three out of 12 students were successful in performing mathematics tasks, but the majority did not experience any success despite their efforts to improve. Eight of them experienced their first major failure in Mathematics when they were in Grade 7 and because their difficulties were not addressed, the gap in needed skills grew wider as their Math courses advanced. They interpreted their successive failures as a sign that they lacked the needed math abilities. Four students showed signs of demotivation, fixed mindset, and learned helplessness in Math.

Vicarious Experiences

Five out of eight students with high MSE levels interpreted their vicarious experiences positively. According to them, their teachers behaviorally modelled passion for Mathematics. Another type of modelling mentioned was verbal; the teachers coached the students on having a growth mindset by telling them that getting a low grade in Mathematics does not necessarily mean that they cannot be good in Math.

Three students with high MSE levels tended to interpret their VE neutrally. These students knew they could perform advanced mathematical tasks, but they did not find their skills essential in their future careers. Some of the students who had average and low MSE levels were encouraged by their teacher's way of teaching at their level like the step-by-step approach of performing mathematical tasks, but they did not see themselves performing like their teachers, especially during major examinations when they could not solve that problem as taught to them in the classroom.

The vicarious experiences from parents were interpreted neutrally by almost all the SHS student participants, except for one student with high MSE. He noted that his father served as the best model in learning Mathematics because his father demonstrated searching for more information for the mathematics concepts that they both did not understand. The vicarious experiences from the peers, on the other hand, were interpreted either positively or negatively. The competitive students with high MSE tended to interpret vicarious experiences with peers as positive because they see themselves capable of being in the level of those who are better than they were. One student with high MSE claimed that he also learned from his peers during peer tutoring. For those with average and low MSE levels, vicarious experiences from peers were interpreted negatively, especially when they compare themselves to or seek help from those who are better than they were. The social comparison led them to feel inadequate in mathematical skills.

Social Persuasion

Social persuasion from adults and peers were interpreted neutrally, negatively, or positively. The majority of science high school students interpreted the feedback and encouragement from their teachers and parents as too general, expected, and familiar that it led them to interpret it as neutral. The social persuasion from their peers validated and affirmed their perceived ability in Mathematics. To those who have high MSE levels, it validated their mastery while those who have average and low MSE level confirmed their non-mastery. One student interpreted the praise he received from helping his peers negatively, because for him to be good in Mathematics, he needed to trade his free time, summer vacation, and weekends for studying math. Some of the students interpreted feedback positively as it served as encouragement to them to continue learning mathematics. Furthermore, they interpreted non-recipient feedback as them doing well.

Physiological and Emotional States

Physiological and emotional states were interpreted both positively and negatively. To those who had high MSE levels, fears, stress, and feeling of nervousness when performing mathematics tasks were interpreted as signs for new learning and enlightenment. One student interpreted lack of sleep and adrenaline rush as factors that energized him. Those who had average and low MSE levels who used to panic when performing mathematics tasks at first, reported that they were able to overcome it and finish the tasks. There were six students with low MSE levels who showed signs of mathematics anxiety that affected their mathematics performance. When they were asked how they felt when they took a math test, their responses included, "*My brain freezes when I study and take the test*."; "*There is a dread(ful) feeling*."; "*I panicked*."; "*Oh no, I can't do that*."

The results of the present study show that among the sources of science high school students' mathematics self-efficacy, mastery experience contributed the most to the students' MSE.

Students with high MSE levels increased their MSE when given challenging math tasks and they looked forward to accomplishing them. On the other hand, as those who had average and low MSE levels experienced successive failures, their MSE decreased, which manifested through avoidance of math tasks that they perceived were beyond their abilities. For the vicarious experience, witnessing their teachers, parents, and peers perform math tasks encouraged and motivated them to not give up but it did not give them the confidence to perform or reach the level of math expertise of the models they were observing. Social persuasion did not affect their MSE as they perceived feedback as general and expected. It is notable that science high school students interpreted lack of feedback for their math performance as an indication that they were doing well. This can be another possible topic of research, to investigate why students perceive that feedback is only given to those who are not performing well. Physiological and emotional states were the least contributing source to the students' MSE as only three students with average and low MSE levels experienced the negative effect of physical and emotional triggers when given a math task. The students interpreted being nervous and lack of sleep positively because according to them, it made them excited to perform a challenging math task.

These results validate the results of different studies which show that mastery experience contributes the most among the sources of self-efficacy (Arslan, 2012, 2013; Hampton, 1998, as cited in Arslan, 2013; Bandura, 1997; Britner & Pajares, 2006; Hampton & Mason, 2003, as cited in Kaya and Bozdag, 2016; Klassen, 2004; Lopez and Lent, 1992; Usher & Pajares, 2006; Usher & Pajares, 2009; Yurt, 2014). Mathematics self-efficacy scores are significantly and positively predicted by student's mastery experience, and competitive goal scores and only mastery goal scores linearly predict student's MSE scores (Joaquin, 2007); and physiological and emotional states are the least contributor to the development of MSE (Lopez & Lent, 1992).

Relationship Among Sources of Mathematics Self-Efficacy, Mathematics Self-Efficacy, and Mathematics Performance

Significant relationships were found between MSE and ME, and MSE and VE at $p < .05$, while SP and PES had nonsignificant relationships with MSE at $p < .05$. This is shown in Table 4 which contains the result of the measurement of the structural model through the PLS-SEM with R. The result means that successful or failed performance of math tasks and vicarious experiences are likely to influence the development of the SHS students' MSE, while praise, feedback, and nervousness are unlikely to affect the level of the SHS students' MSE. The result for ME and VE confirms the literature which shows that the sources of MSE have a significant relationship with MSE (Arslan, 2012, 2013; Usher & Pajares, 2006), though this does not hold for SP and PES.

Table 4

Summary of the Structural Model Path Coefficients of the Sources of MSE, MSE, and MP

	Estimate	Std. Error	T-value	Pr (>|t|)
Intercept MSE	0.0000	0.0637	0.00	
ME	0.3255	0.1107	2.9385	0.0038*
VE	0.2085	0.0956	2.1804	0.0309*
SP	0.1974	0.1055	1.8696	0.0636**
PES	0.0011	0.0880	0.0130	0.9896**
Intercept MP	0.00	0.0648	0.0000	1.00
ME	-0.63321	0.0825	-7.6773	0.00000000000246*
MSE	-0.00798	0.0825	-0.0967	0.92**

*significant at $p < .05$; **nonsignificant at $p < .05$

The qualitative data supported the quantitative results that ME and VE contributed to the MSE of science high school students. The students were asked to rate their perceived MSE and then followed up with what will make them more confident and perform better in math tasks. Their responses showed that mastery experiences like practicing solving more math problems and giving more effort contributed to their MSE. Examples of narratives are, "*If I solve more problems that is according to the level of my abilities*"; "*practice more with increasing difficulty*"; "*Sumali sa competitions (Join competitions [in Math])*"; "*If I can go to their (those who can do better) level*"; "*If I get better grades consistently*"; and "*if I can consistently perform well.*" In addition to mastery experiences, science high school students perceived that getting good grades would increase their MSE, which showed that previous mathematics performance influenced their MSE.

As for the vicarious experiences, the SHS students were more affected by their teachers' expertise. However, only three of those who had HMSE increased their confidence level whenever their teacher gave challenging math problems. By challenging, the students meant that the math problems were not too easy for them nor not too difficult. The rest of the participants appreciated their teachers' expertise, but they were satisfied with their performance and the current skills they already acquired. Those who had LMSE perceived that the Math curriculum in SHS is more advanced than the regular high school students in their level, "*I got into SHS that's why I believe that I have the math abilities. But here in SHS, I wouldn't say that I'm even the best nor do I belong to half of the top students who do well in Math*." And "*I know that outside SHS, Math is usually easier*." This showed that VE's influence is limited to three SHS students but not to all, as they perceived that what would give them more confidence is a better grade in Math.

For the non-significant relationship of SP with MSE, as gleaned from the SHS students' responses, the researcher found out that the students seldom received feedback, encouragement, and praise from teachers, parents, and peers. In the case of the teacher's feedback, most of the time it was general feedback and encouragement such as, "*he is a good student*"; "*you did well*"; "*you can still improve*";

"*you can do better*"; "*you can do it*"; and "*walang bobo sa Math (Nobody's dumb in Math).*" For the parents' feedback, the students perceived it as something that was expected because they are their parents like, "*ang galing ng anak ko (my child is good [in Math]*" and other general comments. Their peers praised them when they were able to help them. Exaggerated praise of abilities was given to those who had a high MSE level that discredited the praise like, "*Wow, you are a math lord*." Thus, SP was not an effective source of MSE for SHS students as it should be something connected to reality and their experiences. It is consistent that the SHS students would like to see the reflection of their math abilities and skills in their Math grades for each source to contribute effectively to the students' MSE.

Finally, for PES, students with HMSE positively interpreted the negative reactions of their body, emotion, and adrenaline rush. On the other hand, four of the students with AMSE and LMSE interpreted fear and worries when taking math exams as a sign of their non-mastery of the mathematics skills. The rest of the students reported experiencing fear and nervousness because of outcome expectation rather than their MSE making PES non-significant as a source of SHS students' MSE.

A nonsignificant relationship also exists between MSE and MP at $p < .05$. This means that MSE is unlikely to influence the SHS students' MP and is supported by the qualitative data revealed by the students' responses attributing their mathematics performance to other factors such as effort and previous mathematics performance. At the same time, the qualitative data showed that the students also tend to underrate themselves, which validates the study about Asian students exhibiting low MSE with high MP (Lee, 2009; Scholz et al., 2002; Usta, 2016).

Predictability Power of MSE

MSE alone is not a strong predictor of the SHS students' MP. The MP's mean redundancy is .4073, which means that approximately 41% of the SHS students' MP is predicted by MSE and ME. Therefore, if the SHS student has a high MSE it does not follow that they will have a high MP. With this, it can be inferred that there are other factors that can predict the SHS students' MP aside from MSE and ME. On the other hand, ME was found out to be a strong predictor at -.633 as shown in Fig. 1. That is, if the SHS students exert more effort towards mastery it can be inferred that they will have a high MP.

The qualitative data in this study supported the quantitative result. When the students were asked about their perception of their Mathematics grade, all of them equated their mathematics performance with the effort they invested in learning the course. They believed that their grade reflected their efforts, understanding, hard work, and the time they invested in studying and learning. Aside from these, eight students gave additional factors that affected their MP such as moods, non-compliance, demotivation, and lack of interest. Six students who experienced a series of failures and inconsistent mathematics performance made them feel inadequate and lacking in mastery. Therefore, SHS students' MP is predicted more by other factors than MSE. A further study on these factors is recommended.

Conclusion

Science High Schools play a crucial role in the country's national development as they serve as the main STEM pipelines. The advanced curriculum and training help in preparing scholars for STEM-related professions. In addition, they must have a firm belief in their abilities and skills to encourage them to continue their path towards STEM. Thus, the result of the present study is essential in creating intervention to retain the SHS students' motivation to stay in the curriculum through their belief that they can successfully accomplish math-related tasks.

As shown in the result of the quantitative data and supported by the qualitative data, among the Mathematics Self-Efficacy sources, mastery experiences contributed the most to the SHS students' mathematics self-efficacy. Students with high Mathematics Self-Efficacy interpreted their

success and setbacks in performing mathematics tasks positively, affecting their likelihood to seek more challenges and persevere in accomplishing the assigned mathematics tasks. In contrast, those with average and low MSE levels interpreted their failures and setbacks as negatively affecting their likelihood of performing mathematics tasks.
This gave rise to avoidance of challenging mathematics tasks, fear of failing, and feeling of inadequacy. One form of avoidance is deciding not to take higher Mathematics courses anymore. Another form of avoidance is not engaging in mathematical tasks beyond what was required in class such as joining extra-curricular activities related to Math.

Therefore, it is crucial to consider the level of difficulty of mathematics lessons depending on the students' level of mathematical skills and abilities. Pajares (2006, as cited in Usher, 2009) states that "academic work should be hard enough that it energizes, not so hard that it paralyzes" (p.344). Clark (1999) emphasizes that there is a point in the individuals' cognition that their cognitive load exceeded the working memory capacity of their brain. This cognitive overload leads to a "default response" such as avoidance, devaluing of activities they perceive to be difficult for them, helplessness, or diverting to other things where they find novelty in its sense or believe that they could accomplish better.

Among the four sources of MSE, SHS students' ME and VE are the ones that have a significant relationship with their MSE. SHS students showed a tendency to compare themselves with their peers and set their standards according to who is the best in their batch. Peer and teacher's modelling are effective only for those who have high MSE level as they perceive it as helping them understand the lesson and be challenged to perform better. On the other hand, peer modeling is ineffective for those who have average and low MSE levels.
They appreciated their peers and teachers' expertise and mastery, but these did not help them to successfully perform the mathematics tasks assigned to them. Furthermore, seeing their peers performing better in Mathematics made them feel demotivated and helpless as they only experienced successive failures in their attempts. Parents modeling is ineffective as well, as it was only limited to mathematics applications through household chores. The findings also support literature that showed the effect of social comparison, where students are expected to learn how to learn and evaluate their potentials using the learning outcomes rather than meeting the approval of one's in-group (Ames, 1992; Dweck & Legget, 1988; Nicholls, 1984, as cited in Oettingen & Zosuls, 2005). Therefore, SHS students' MSE is influenced more by ME and VE.

On the other hand, SP and PES have a nonsignificant relationship with the SHS students' MSE. They perceived feedback, encouragement, and praise that they received as too general and common. 16 SHS students found it difficult to affirm their mathematics ability in SHS, as they perceived that there were far better students than them. Praise did not count either as it depended on the perceived difficulty of the specific math task. This is in line with what Reivich (2010, as cited in Torres, 2015) argues that "empty praise that is not based on a child's actual talents and skills will not enable the children to form constructive beliefs about their abilities" (p. 88). PES can be interpreted positively or negatively. For those who had HMSE level, they interpreted physical and emotional signals positively, such as adrenaline rush which gave them energy and kept them more alert. For those who had LMSE levels, some experienced a level of distress such as panic that led them to be hopeless. Five of the students mentioned that they gave up in the middle of the test or wrote random numbers on their test papers, which may be a sign of mathematics anxiety and can further affect the individuals' MSE and math performance. Individuals who view a heightened level of anxiety as threatening are generally less confident in their academic capabilities compared with those who interpret these feelings as energizing (Chen & Usher, 2013). But they also mentioned that they didn't need to exert more effort as they would not be needing very advanced math skills in their desired college course. Therefore, SP and PES did not have much influence in the development of SHS students' MSE.

The mathematics performance of the SHS students was not affected by their confidence in their abilities but rather by the effort they put into learning the mathematics skills. They believed that they could learn it in time and with more effort, but those with AMSE and LMSE lacked the willingness to do it. For those who had HMSE level, they did not want to advance since it was not relevant to their future career, and they already established their MSE. Those who had AMSE and LMSE were demotivated because of previous unsuccessful experiences. Still, at the same time, they knew that compared to non-SHS students, they were more advanced, and what mattered was that their Mathematics in high school prepared them for college. At the same time, SHS students also showed a tendency to underrate themselves which is consistent with literature on Asian countries which showed that despite having low mathematics self-efficacy they have high mathematics performance (Eaton & Dembo, 1997; Klassen, 2004; Lee, 2009; Usta, 2016).

Therefore, MSE does not predict the SHS students' MP. SHS students referred to efforts and hard work that affected their grades. They were also satisfied with the skills that they had developed which prepared them for their college course. With this, it is recommended to look into the outcome expectations as another factor that may affect the SHS students' MP. According to the framework of Social Cognitive Career Theory (Lent, et al., 1996), learning experiences affect self-efficacy and outcome expectations, and outcome expectations may affect the students' actions that will affect their performance domains and attainments.

Recommendations

The result of the study showed that SHS students had an average MSE level even if they had good mathematics performance. The sources of MSE had a less to moderate effect on the SHS students' MSE development. According to research, self-efficacy is an important predictive index of career choices (Lent et al., 1996; Nauta, 2007; Rottinghaus et al., 2002). MP is positively associated with a career choice in STEM (Crisp et al., 2009; Wang, 2013). As science high schools serve as the primary source of scientists in the country, SHS students must take STEM-related courses.
The following interventions to increase the influence of each source in the SHS students' MSE development are recommended.

SHS students mentioned that SHS has an advanced Math curriculum. However, students came from different grade schools with varying backgrounds in math; while some students are advanced in their mathematics skills, others may not have mastered the basic skills to perform advanced math. It is then recommended that the SHS conduct a bridge program or enrichment in mathematics as the students enter the 7th Grade. This will help the students master the skills needed for the advanced curriculum in Math.

SHS students fear failing due to high expectations from parents, teachers, school community, and themselves as scholars. Still, failing in math performance is not something that should be avoided, but a series of failures despite all efforts and time invested in studying for a high-stake exam should be limited. Therefore, math tasks should be divided into chunks and let the students experience overcoming the increasing difficulty of the math tasks through scaffolding. Providing alternative assessments can be helpful such as portfolios, observations, and collaborative work in modeling problem solving given a real-world setting, and reflection papers instead of a series of high-stakes summative assessments.

SHS students showed that they had an average MSE because they compared themselves with others better than them. They didn't mention the Math learning objectives in comparing themselves but they looked for the best performing student and then rated themselves. Thus, it is suggested to develop mastery goal oriented SHS students to set more specific personal mastery goals rather than compare themselves with others. Through this, it will increase their motivation to learn math, as Latham and Locke (1991) suggest that "the simplest and most direct motivational explanation of why some people perform better than others is because they have different performance goals” (p.213).

SHS students seldom receive feedback for their math performance and they interpret non-reception of feedback as them doing well. This also shows that they perceived that feedback is given only to students who needed improvement in their performance of math tasks. Thus, for feedback to be more effective and help the development of their MSE, it should be given at the right time, sincere, should be realistic, and should aim to clarify, enlighten, and affirm. Furthermore, it should focus on processing the performance of the math tasks, what the students did best, and what can be improved.

On the interpretation of physiological and emotional states, it is recommended to introduce social-emotional learning (SEL) to the SHS students. Through integrating SEL activities in Math lessons, students can develop self-awareness which include linking feelings, actions, and thoughts, and a growth mindset. This can also help in developing the ability to regulate and control their thoughts, behavior, or emotions, and change them depending on the situational and contextual demands (Wenger, 1998, as cited in Grothérus et al., 2019).

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