Students' mathematics achievement in Mindanao context: A meta-analysis

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ARTICLE INFO	ABSTRACT
	Over the years, there have been several studies exploring the factors affecting mathematics achievement. However, no study, specifically in the Mindanao context has attempted to summarize or illustrate the model for these sets of studies. This study aims to analyze the overall effect size of the factors on the student's achievement in mathematics. The causal-comparative research design was utilized to synthesize the existing research about the student-related, teacher-related, and school-related factors that have -greatly influenced students' mathematics achievement. Through the use of a multi-stage sampling design, 200 existing studies were funneled down to 50 with 158 effect sizes which met the inclusion criteria coming from the different colleges and universities in Mindanao. To determine the significant factors be included in the model that significantly influence students' achievement, Hierarchical Linear Modeling (HLM) was utilized. The findings revealed that the overall effect sizes have a small effect on mathematics achievement. On the other hand, mathematical skills, attitude, and self-efficacy are found to be the predictors of students' mathematical achievement. Further, it was concluded that the type of school where the student is studying could cause significant variation in the effect sizes. It is recommended that educational institutions may review regularly the curriculum addressing the disparity of achievement between public and private schools. Also, teachers may utilize varied teaching strategies so that students would develop interest and positive learning attitudes towards mathematics.

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Introduction

Over the past decades, researchers have succeeded in determining the different factors that significantly influenced student's achievement, particularly in mathematics. Evidently, researchers pointed out that the school type factor significantly predicts learning mathematics. They noted that public school students make more gains in mathematics assessment than private schools (Reardon, Cheadle & Robinson, 2009; Lubienski, Lubienski & Crane, 2005). However, contrary to the above observation, the study of Bernardo, Ganotice, and King (2014) revealed that public schools had lower achievement than private schools.

Another factor that predominantly predicts student's achievement in mathematics is attitude. In the study conducted at Standford University, it was found that a positive attitude toward mathematics accelerates the memory of the brain and predicts mathematics performance (Chen, Bae, Battista, Qin, Chen, Evans & Menon, 2018). Ellis (2010) stressed that a positive attitude affects a student's achievement. Singh, Granville, and Dika (2002) revealed that motivation, positive attitude, and engagement in academic work create success in mathematics and science. This finding is similar in the study of Burris, Heubert, and Levin (2006) that motivation affects attitudes by causing students to be positively confident in learning mathematics.

Moreover, the self-efficacy factor is also attributed to students' performance. Studies have confirmed that self-efficacy beliefs influence achievement (Ecarma, 2012; Hisola 2013; Murray, 2013). Moreover, Onyeizugbo (2010) found that self-efficacy is positively correlated with the academic performance of the students, but disagreed with the results of Hailikari (2007) who found that self-perception does not directly influence student achievement at any course level. Simbulas (2014) supported the notion that self-efficacy does not directly affect students' achievement in math because he found a negative correlation between students' self-efficacy and academic performance in Algebra among private non-sectarian schools.

These accumulated findings have not been summarized or relatively compared because many studies demand highly developed and complex statistical analyses and techniques in measurement. Gabales (2010) and Japay (2016) stressed that data from different researches should be viewed as multifaceted data points, to point in a single study, and make it more understandable even without the full utilization of statistical analysis.

However, in 2017, Visible Learning Plus published Hattie's (2017) updated list of factors influencing students' achievement. These factors include the things that teachers, school leaders, students, or parents can control or influence and its corresponding impact value in each factor. Despite the determination of each factor effect size, there were no recorded studies that would synthesize the interaction or the combination of these hierarchical factors in mathematics achievement in the Philippines, specifically in Mindanao.

Meanwhile, the Philippines ranked 2nd from the bottom among the participating countries in the recent Programme for International Student Assessment (PISA) 2018 according to DepEd - National Report of the Philippines (2019). This alarming result revealed that Filipino students recorded a mean score of 353 points in Mathematics Literacy which is significantly lower than the OECD mean of 489 points. It is also reported that only 1 out of 5 Filipino students or approximately 19.7% attained at least the minimum proficiency level (Level 2) in Mathematics Literacy.

However, the 2015 Review Report on the Philippine Education for All on National Achievement Test stated that while the Filipino learner's NAT mean percent score (MPS) has increased over the eight years (2005-2013), it has not yet reached the 75 percent MPS target. Elementary level NAT is 6.12% points away from the target; while secondary level NAT is 23.59% points away from the target.

Based on the extensive review of the literature of this study, factors that positively influence students' achievement in mathematics are categorized into teacher-related, student-related, and school-related. These factors were at an overlapping hierarchy of influence in mathematics achievement. With this, educators should not only focus on addressing one factor rather, but they should also look into all factors that contribute to the success of students' achievement in school.

In this context, the need to determine the prevailing factors that greatly affect students' performance is indispensable. The inconsistencies of the preceding research findings need to be resolved to find out what factors influence students' achievement not only in mathematics but also in other content fields. Since teachers play an important role in the success and failure of students in school, it is worth noting that teachers must be mindful of the factors contributory to lifelong learning (Andaya, 2014).

Thus, this study aims to analyze the overall effect sizes and identifies the factors of a student's mathematical achievement using hierarchical linear modeling. This study sought to find out the overall effect size of the included studies, the specific student-related, teacher-related and school-related factors that have a significant effect on students' achievement, and the factors that could cause significant variation of the effect sizes. Ultimately, this study provides a hierarchical linear model of the factors which have a strong influence on students' achievement. The following null hypotheses were tested at alpha 0.05 level of significances: there is no factor that could cause significant variation of effect sizes; and there is no hierarchical linear model that could provide a strong influence on students' achievement.

This study offers a model for framework development to increase achievement in mathematics and further improve school performance by enhancing and addressing the factors affecting achievement. This would serve as a guide for curriculum specialists, administrators and policy-makers to modify existing school rules, regulations, and internal modalities that constraints teacher and students in the learning process.

This meta-analysis study was delimited to existing studies about factors affecting students' achievement in mathematics. The studies subjected to meta-analysis were unpublished theses and dissertations and published research journals that fit the inclusion criteria. It covered quantitative studies conducted in the Philippine setting specifically from the three Mindanao regions (R-X, R-XI, and R-XII). Also, the study used the student version of HLM where only seven variables or factors can be accommodated in running the HLM.

Research Methods

Research Design

This quantitative study utilized a causal-comparative research design. This is the best approach to be used in comparing two or more groups to find differences or determine whether the independent variable affects the dependent variable (Schenker & Rumrill, 2004). In this meta-analysis, the effect sizes from different researches were translated and explored using a common metric and statistics to show the characteristics of research variables and findings and its linkage to students' achievement. The collection of research studies, coding, and interpretation of research findings were used as the primary data.

Research Locale

The study was conducted in three different regions in Mindanao particularly in Northern (Mindanao Region X), Davao Region (Region XI), and SOCCSKSARGEN (Region XII). The manual search of the list of thesis and dissertations from selected universities and colleges across the three regions was conducted. These higher education institutions offer masters and doctorate programs in Mathematics Education.

Sampling Design

In identifying the research studies to be included in the meta-analysis, a multi-stage sampling design was used in this study. First, studies must be quantitative researches conducted in the Philippine context from 2005 onwards. Second, they must indicate the

relationship between the two variables, teacher-related factors, student-related factors and school-related and student academic achievement. Third, student academic achievement was affected by student factors and/or teacher factors and/or school factors. Fourth, the authors used an outcome variable that measured student academic achievement and studies that specifically measured student achievement in Mathematics. Fifth, the independent variables were quantified and measured through valid and reliable assessment tools while the dependent variable was also quantified or measured through grades or other assessment procedures used by the authors. Sixth, the effect sizes were determined from the statistics. Seventh, they must have identified different characteristics of the moderator variables.

However, individual studies were excluded and eliminated if they did not meet the selection criteria. Specifically, if it is qualitative researches and quantitative researches which does not have enough statistical data for analysis or the studies which used only percentages and there were no statistics.

The procedure of the Study

First, the endorsement letter to conduct the study was secured. Then, the researcher did the manual and online search for the studies to be included in the analysis from various higher educational institutions in Mindanao after the focus of the study was defined.

The selection criteria which were utilized to consider both published and unpublished study and the findings were empirical data. The criteria for the final selection of the studies to be included in the paper specified that the study must include factors, such as teacher-related, student-related, and school-related as independent variables. Moreover, the study must also use students' achievement (or success, performance) as the dependent variables. Furthermore, the study must use the experimental, quasi-experimental, or correlational design of the study. In addition, it must have means, standard deviations, p-values, ANOVA tables, t-values, etc. Lastly, it must be dealt with general students or classes.

The coding of the data followed after the relevant studies were identified. Since this study was a meta-analysis utilizing HLM, this mainly used the qualified existing secondary data. A coding sheet was made to organize and code the statistics of each study. This coding sheet controlled the selection criteria and other characteristics important for this study. In this rigorous process, substantial information on the select studies was transferred using the coding sheet. However, studies that did not possess the information required for this study were eliminated. After encoding, it was followed by analysis and interpretation of data.

Data Analysis

In this meta-analysis study, inter-rater reliability, effect sizes conversion, and Hierarchical Linear Modeling (HLM) were used to analyze the gathered effect sizes in various qualified research studies. The inter-rater reliability was established through a subset of five (5) select studies which were coded by three (3) raters and the level of agreement among the raters was calculated using Cohen's kappa statistics. Conversion of effect sizes was used to have a uniform metric in analyzing the effect sizes of the gathered data under study. If the study reports an-value, this effect can be automatically included in the meta-analysis without conversion. However, some studies that used t-value and F-ratio were being coded and transformed into common metric r. This was done using the effect size calculator available online for free such as Colorado Springs' Effect Size Calculator, Effect size Calculator (Cohen's d). Then, the excel spreadsheet was used to convert effect sizes r to Fisher's z to ensure the variables are normally distributed.

Moreover, this meta-analysis study utilized hierarchical linear modeling. HLM is a multifaceted form of ordinary least square (OLS) regression that is employed in analyzing variance in the outcome variables when the predictor variables are at varying hierarchical levels – school level, classroom level, and student level. HLM is useful in understanding the relationships of hierarchical data structures like students within schools. Before conducting the HLM, the following assumptions must be met: the transformation of the effect sizes; the outliers and test of normality; multicollinearity and singularity in running HLM.

Results and Discussion

Descriptive Statistics of the Effect Sizes

The effect sizes of the different studies were considered as a unit of analysis for this meta-analysis utilizing HLM. These effect sizes were the values that quantify how effective a certain factor or intervention is to mathematics achievement. Effect sizes were synthesized to determine whether these will significantly differ from zero or whether the estimates are reasonably consistent across varied studies (Gardner,n.d).

Table 1 shows the descriptive statistics of the raw and transformed effect sizes as the units of analysis in this study. With the 158 effect sizes recorded, the observed raw effect sizes varied from small to large that range from -0.233 to 0.604 (M=0.149, SD=0.762). According to Cohen (1988), the effect size is small if the value lies between 0.1 to 0.29 or lower. This indicates that on average, the factors have a small effect on the students' achievement in mathematics.

Table 1

Descriptive statistics of the effect sizes

	N	Minimum Value	Maximum Value	Mean	SD
Raw Effect Sizes	158	-0.233	0.604	0.149	0762
Transformed Effect Sizes	158	-0.237	0.699	0.157	0.275

In the final data analysis, the raw effect size was transformed to Fishers' z which normalizes the distribution of r. According to Anderson (2003), Fisher's z transformation pertains to the function of r whose sampling distribution of the transformed value is close to normal. In the transformed effect sizes, the mean and standard deviation across the studies revealed (M = 0.157, SD = 0.275) which also implies a small effect. This means that the effect sizes of the factors included in the studies have a small effect on the achievement of students in mathematics.

Hierarchical Linear Modeling Level 1

After the identification of the factors that could affect student achievement, all factors except for teaching pedagogy which does not belong to level 1 factors were run through HLM level 1. These included variables like mathematics skills, self-efficacy, and attitude.

Table 2 shows the unconditional means model also referred to as a one-way random effect ANOVA, which is the simplest possible random effect linear model. This aims to test whether factors have an effect or influence on the students' achievement in mathematics.

Table 2
Hierarchical Linear Modeling (HLM) result for level-1

Parameter	Ƴ	SE ƴ	t-ratio	p-value
Factors and students' achievement	0.287	0.013	22.158	0.000
Mathematics Skills	0.408	0.034	11.817	0.000
Self-efficacy	0.021	0.004	5.485	0.000
Attitude	-0.160	0.019	-8.252	0.000

Sigma squared (σ^2) = 0.031
$V(u_o)$ = 0.020
Chi-square (x^2) = 901.28 (238), p = 0.000
Deviance = -340.121

As reflected in Table 2, the model in a single equation is represented by Achievement = $G_{00} + u_0 + r$. The results indicate a mean size of 0.287 across studies, considered moderate according to Cohen's interpretation. This further indicates that t (238) = 22.158, p < 0.05, is statistically significant. It means that students' achievement in mathematics is significantly affected by the variables at the student level. Moreover, the test of homogeneity and the chi-square test shows significance; thus, the studies are not homogenous, and the measures of effect sizes differ because of the factors other than sampling error. Therefore, this positive association implies that factors affect the performance of students in their achievement in mathematics.

The result shows that student-level factors scilicet mathematics skills; self-efficacy and attitude significantly influence students' performance in mathematics. As presented in Table 2, mathematics skills registered t = 11.817, p < 0.05. This means that the mathematical skills of students significantly predict their mathematics achievement. This implies that the students' level of fundamental skills in numbers and number senses, geometry, measurement, statistics and probability, patterns, and algebra would determine their achievement in mathematics. Further, it indicates that the better the numerical skills of the students the better achievement they would have in mathematics. It has been observed that those students whose mathematics' achievement scores were high were really good in basic operations on integers. Unfortunately, most of the students have not yet mastered these number skills especially those dealing with fractions.

The findings of this study were validated by Salvan (2014) who found that basic mathematics skill was one of the factors that influenced students' achievement in mathematics. Also, Siegler and Pyke (2013) pointed out that elementary mathematics skills and students' knowledge of fractions and divisions predict their achievement in mathematics during high school.

Meanwhile, another significant factor that influences students' performance is self-efficacy as revealed in this study. The results show that this factor has a t-value of 5.485 and p < 0.05. This means that the level of the students' confidence in solving mathematical problems would predict its mathematics achievement level. The results suggest that students should believe in their capabilities in dealing with real-life math problems for this would determine better achievement in mathematics. Thus, students must possess confidence in fulfilling several tasks pertinent to mathematics and understanding the complexity of mathematical problems.

This result is supported by the studies of Ekuri and Offiah (2018), Ecarma (2012), Hisola (2013), and Murray (2013) who stated that mathematics self-efficacy of students significantly predicts mathematics performance. Additionally, Onyeizugbo (2010) concluded that there is a positive correlation between self-efficacy and academic performance. Moreover, in the study conducted by Tekola, Getahun, and Hagos (2019), it was revealed that there were gender similarities in teacher affective support and mathematics achievement. Specifically, females found to be more self-efficacious towards mathematics than males.

However, the result disagrees with the findings of Hailikari et al. (2007) who found out that self-perception did not directly influence student achievement at any course level. Further, Simbulas (2014) proved that self-efficacy does not influence the academic performance of first-year private non-sectarian high school students in Algebra.

Attitude (t = -8.252, p < 0.05) shows significant influence on students' achievement in mathematics as revealed in this study. This means that the like and dislike of students for the mathematics subject affects their achievement. This further indicates that students' disposition towards mathematics could determine their achievement in the subject. If a student does not like math this would result in a low achievement in the subject.

Some of the underlying reasons why students do not like mathematics are the notion that mathematics would not help them earn a living and they could see out the usefulness of mathematics in their daily lives. With this mindset, the students feel reluctant about math and this would lead them to attain a low achievement.

This result is reinforced in the study of Ali (2013) and Mensah et al. (2013) which found that student's attitude was a major predictor of their performance. Also, the findings were congruent with the claim of Mbugua et al. (2012), and Choi and Chang (2011) that student's positive attitude towards mathematics had a positive effect on his or her achievement. Similarly, Ramírez (2003) found that 4th graders with more positive attitudes toward their studies attained substantially higher mathematics scores than students with more negative attitudes.

Hierarchical Linear Modeling Level 2

Table 3 presents the result of HLM level 2. It shows that school location (t=9 -1.063, p= 0.289) and pedagogy in teaching (t= -0.337, p = 0.736) both registered insignificant relationship with academic achievement. This means that the geographical site of the school does not affect students' achievement. Also, pedagogy in teaching mathematics does not influence mathematics achievement. This was supported in the study of Lagrimas (2018) stating that there is no significant relationship between teachers' strategy and students' mathematics achievement.

However, school type statistics (t= -2.230, p= 0.027) implies that among the level 2 variables only school type shows significant relationship. This means that school type is a significant factor that causes variations of the effect sizes in student academic achievement. This means that school type affects the achievement of students. Thus, it would lead us to the rejection of the null hypothesis (Ho$_1$) which states that there are no factors that could cause significant variation of the effect sizes.

This result concurs with Ajayi (2006) who found that school type makes a difference in students' academic achievement. Macalisang (1992) confirmed that the type of school had a significant relationship with students' academic performance.

Table 3
Hierarchical Linear Modeling (HLM) result for level 2

Parameter	Y	SE ý	t-ratio	p-value
Intercept	0.300	0.015	20.276	0.000
School Location	-0.023	0.022	-1.063	0.289
School Type	-0.060	0.027	-2.230	0.027
Pedagogy in Teaching	-0.001	0.004	-0.337	0.736
Mathematics Skills	0.404	0.035	11.413	0.000
Self-efficacy	0.022	0.004	5.484	0.000
Attitude	-0.161	0.019	-8.292	0.000

Sigma squared (σ^2) = 0.031
$V(u_o)$ = 0.019
Chi-square (x^2) = 882.108 (235), p = 0.000
Deviance = -324.462

Meanwhile, the four predictors, namely: mathematics skills, self-efficacy, attitude, and school type, have been considered in the model since these variables significantly predict (p<.05) the mathematics achievement. The model below provides a strong influence on students' achievement across study characteristics:

$$y = 0.30 - 0.06 (x_1) + 0.40 (x_2) + 0.02 (x_3) - 0.16 (x_4)$$

In this meta-analysis, the model reveals that students already acquire 30 percent on mathematics achievement (y) without the inclusion of the predictors, holding other factors constant. The students' achievement varies for every type of school (x_1) at about 6 percent. The result also indicated that mathematics skills (x_2) provide a strong influence by 40 percent on mathematics achievement, while self-efficacy (x_3) only registered 2 percent predictive value. However, the attitude (x_4) towards mathematics recorded 16 percent negatively influenced by students' mathematics achievement.

Moreover, the model exposed that for every type of school whether public (0) or private (1), there is a corresponding decrease of 0.06 on the outcome variable. Data also imply that for every unit increase in mathematics skills, a 0.40-unit increase is achieved in mathematics. In addition, the model reveals that for every unit increase on self-efficacy, there is a 0.02 unit of improvement in mathematics achievement. Lastly, for every unit increase of the students' attitude in mathematics, it has a 0.16 decrease or improvement in their achievement in mathematics subjects. This increase or decrease occurred when the other variables are held constant. If other variables change, there will be changes that have not been detected.

This means that for every unit increase on students' mathematics skills and self-efficacy there will be a corresponding unit increase in mathematics achievement of students in public schools. Conversely, for every unit decrease of students' negative attitude and enrolled in public schools, there is a negative influence on the students' achievement in mathematics.

Further, the results suggest the rejection of the null hypothesis (Ho$_2$) which states that there is no hierarchical model that could provide a strong influence on students' achievement across the study characteristics.

Since the result shows that mathematics achievement is influenced by the level 1 variables (mathematics skills, self-efficacy, and attitude towards the subject and further varies in school type (level 2), the study conforms to the Bronfenbrenner's (1979) theory on an ecological system that explains that children's development is fueled by their biology which serves as their primary environment. Thus, this environment has complex layers specifically student-related factors (microsystem), teacher-related factors (mesosystem

and exosystem), and school-related factors (macrosystem and chronosystem) that demonstrate the diversity of interrelated influences on child's development. Also, this study strengthens Biggs's ([1987](#)) 3-P model of learning, which believed that "layers" of the environment affect the child's development and learning outcomes of students are a product of a learning system that interacts with each other.

Based on the hierarchical model of this meta-analysis, it can be theorized that mathematics achievement varies according to the type of school and is positively influenced by mathematical skills and self-efficacy, but is influenced negatively by students' attitude.

This proposed theory stresses that school type where the learner studies from greatly affect his/her achievements in mathematics. The impact of the type of school whether private or public plays an important role in determining the achievement in mathematics of the student according to self-efficacy and mathematical skills. Moreover, attitudes towards mathematics affect achievement negatively. This may be due to the notion of students that mathematics is hard, complicated, and a boring subject; and teachers are strict. Having these states of mind would lead to a negative effect on mathematics achievement.

Conclusion

Based on the results of this study, the following conclusions are drawn: First, the recorded overall effect sizes had a small effect on students' achievement in mathematics. With the limited studies in Mindanao, future works and studies may take into consideration larger samples to provide strong statistical analysis and solid evidence of the factors that influence the mathematical skills of the students.

Second, the school type was a significant factor that causes variations of the effect sizes in students' academic achievement in mathematics. It is recommended that educational institutions may review regularly the curriculum addressing the disparity of achievement between public and private schools. A needs assessment should be done to identify these factors.

Third, the three factors, namely: mathematics skills, attitude, and self-efficacy have a significant effect on the achievement of the students. Teachers may create and provide opportunities for students to enhance and improve their mathematical skills. Solving real-life mathematics problems and playing math-related games may be considered. Moreover, to improve students' self-efficacy, teachers should let the students work on mathematics problems out loud.

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