EXAMINING FACTORS INFLUENCING STUDENTS' ACHIEVEMENT IN MATHEMATICS USING HIERARCHICAL LINEAR MODELING

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This paper highlights the results of HLM to examine the factors that could influence students' achievement in mathematics in public schools in Cotabato City, Philippines. This involved 638 Grade Six elementary and Fourth Year high school students and 24 mathematics teachers. Survey questionnaires that were validated and verified using CFA and Rasch modeling, respectively, were administered to both teachers and students. Raw scores were transformed to measures before HLM was performed. The HLM results show that father's educational (FED) attainment and mathematics anxiety (MAS) have a significant influence on mathematics achievement. In addition, enhanced teaching practices (EATP) directly influence mathematics achievement, while mathematics teaching outcome expectancy (MTOE) interact to influence the relationship between MAS and mathematics achievement. Implications to mathematics teaching practice are discussed.

INTRODUCTION

Students' low performance in mathematics, whether in national or international tests, has been a concern in many educational systems including the Philippines. There have been several studies carried out to examine the factors impacting students' performance in mathematics (e.g. Lockheed, Fuller, & Nyirongo, 1989; Savaş, Taş, & Duru, 2010). Factors such as students' gender and socio-economic status (SES) (Ewumi, 2012; Özdemir et al., 2014), parental involvement (Sheldon & Epstein, 2005), environmental factors, such as school or classroom climate (Malik & Rizvi, 2018), and students' self-efficacy (Peters, 2012) are just few factors examined and found to have significant influence on students' mathematics performance. One of the most prominent factors considered to have greatly influenced students' performance is the teacher. Teachers have constant and direct contact with students on a daily basis. Several studies have already been conducted to examine teacher-level factors that influence students' achievement. Students' demographic profile and attitudes toward mathematics also play a role in students' learning (e.g. TIMSS studies).

While there are several studies that have looked into students' achievement in mathematics and the factors affecting it, there is a dearth if not an absence of similar research in the Philippine context using multi-level analysis techniques, such as hierarchical linear modeling (HLM). This specifically aims to examine using HLM the teacher- and student-level factors that may have a direct or indirect influence on students' achievement in mathematics in Cotabato City, in Southern Philippines. The data collected for this study are clustered on two levels – teacher level and student level. Teacher-level factors involved are gender, level of education, years of teaching experience in mathematics, efficacy beliefs in teaching mathematics and teaching practices. Student-level factors taken into account are gender, parents' educational attainment, confidence in learning mathematics, and mathematics anxiety.

LITERATURE REVIEW

Studies conducted related to factors influencing students' mathematics achievement have revealed varying findings among countries. In some studies, it was found that teachers can influence students' performance as much as the students themselves. This was found to be true in Singapore, but not in the USA in the study conducted by Ker (2015), which investigated on the student-, teacher- and school-level factors that impact students' mathematics achievement. This study compared the data from TIMSS 2011 results between Singapore and the USA. Using HLM, Ker inferred that, in Singapore, of the five variables that significantly correlate with average

students' achievement, four were teacher-level factors. These factors include teacher career satisfaction (TCS), confidence in teaching mathematics (CTM), school/teacher emphasis on academic success and mathematics instructional hours per week (MHW), whereas, in the USA, only CTM significantly affected students' achievement.

In support of the claim that students' achievement is affected more by student-level factors, Choi and Chang's (2011) study reveal that more student-level variables were found to have significantly affected student's mathematics achievement. The findings reveal that parents' educational level had a significant positive effect ($\beta3$ = 4.24, p < 0.01) on students' performance. Student's gender was likewise found to be statistically significant, indicating that girls, on average, scored lower than boys on mathematics achievement. Further results reveal that students' attitudes toward mathematics also had a significant effect on their mathematics performance; that is, when a student had a positive attitude toward mathematics, he or she, on average, scored higher on mathematics performance. It was therefore interesting to find out if these hold in the Philippine context.

METHODOLOGY

There were 638 Grade Six elementary and Fourth Year high school students and 24 mathematics teachers of public schools in Cotabato City who participated in the study. Grade Six and Fourth Year level students sit for the National Achievement Test (NAT) administered by the National Education and Testing Research Center (NETRC) of the Department of Education (DepEd). The NAT is a standardized test administered every year towards the end of the school year. Students' score in mathematics was used as the measure of achievement.

Survey questionnaires were administered to both teachers and students. At the teacher-level, the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) was used to measure teachers' beliefs in teaching mathematics. This was adopted from Enochs, Smith, and Huinker (2000). It consists of 20 items with five-point Likert-type scale, ranging from "strongly disagree" to "strongly agree" with two uncorrelated dimensions, personal mathematics teaching efficacy (PMTE) and mathematics teaching outcome expectancy (MTOE). Teaching Practices Scale (TPS) was adopted from the Teaching and Learning International Survey (TALIS, 2008). This consists of 18 items with five-point Likert-type scale ranging from "never or hardly ever" to "in almost every lesson." This has three correlated sub-scales, structured teaching practice (STP), student-oriented teaching practice (SOTP) and enhanced-activities teaching practice (EATP). At student-level, both Confidence in Learning Mathematics (CLM) and Mathematics Anxiety (MAS) scales were adopted from Fennema and Sherman (1976) Mathematics attitude scales. Both have a five-point Likert-type scale which ranges from "strongly disagree" to "strongly agree." Higher scores in all the scales imply a higher level of the construct being measured, except for the MAS, where a higher score indicates a lower level of anxiety.

The MTEBI, TPS, CLM, and MAS all underwent construct validation by using confirmatory factor analysis (CFA) employing Mplus. The scales were further examined at the item-level by using the Rasch model. The weighted likelihood estimates (WLE) of the four scales, obtained using Conquest after item validation, are then used in the conduct of hierarchical linear modeling (HLM).

ANALYSIS AND RESULTS

This study employed the Hierarchical Linear Modeling (HLM) version 6 (Raudenbush, Bryk, & Congdon, 2005) software to conduct multi-level analysis to examine the factors that influence or affect students' mathematics achievement (Level 1 outcome variable). The multi-level analysis was more appropriate as, by nature, students (Level 1) would be considered as nested within

classrooms (Level 2), thus the observations are not fully independent (Osborne, 2000). Treating the multilevel data as single-level may lead to misinterpretation of the effects and increase the probability of rejecting the null hypothesis. Also, it is hypothesized that different teaching practices have varying effects on students; hence, the three sub-scales of TPS were used instead as level 2 predictors for the purpose of examining which specific TPS subscales would affect students' mathematics achievement.

After predictor variables in both levels have been added, only the significant predictors have been considered. This results in the final model shown below:
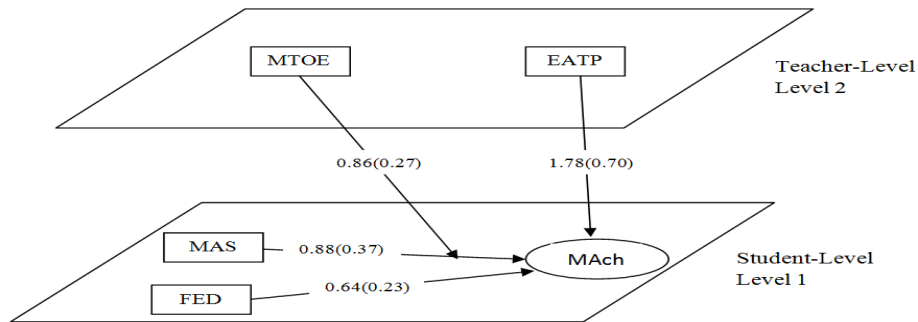

Figure 1 *HLM Model for Mathematics Achievement with path coefficient and robust standard errors*

The unconditional (null) model revealed an intraclass correlation (ICC) of .46, which means that 46% of the variance in mathematics achievement is between-class and 54% is between students within each class/teacher. Among the six predictor variables at the student level (Level 1), only the father's educational attainment (FEd) and mathematics anxiety (MAS) have a positive and statistically significant influence on students' achievement. This means that the higher the fathers' educational attainment, the better the student performs. In parallel, the less anxious the students are the higher their mathematics achievement. At Level 2, two variables significantly affect students' achievement with EATP having a direct and positive effect; MTOE shows significant cross-level interaction with mathematics anxiety. This means that the strength of the relationship between MAS and mathematics achievement is influenced by MTOE.

DISCUSSION AND CONCLUSION

Most studies relating to gender and mathematics achievement have shown that males generally perform better. In this study, however, gender (both at Level1 and Level 2) did not appear to be a factor in students' achievement. This result is contrary to what Demir and Kilic (2010) have found in their study involving Turkey students who participated in the Programme for International Student Assessment (PISA). They used two levels Bernoulli model to examine the factors affecting mathematics achievement.

This study reveals that the father's highest level of education positively influences students' achievement in mathematics as compared to their mother's educational level. This implies that the father's highest level of education tends to influence more their children to perform better in mathematics. Contrary to this result, Lockheed, Fuller, & Nyirongo (1989) found that mothers' higher levels of education had a positive effect on mathematics achievement among eighth-grade students in Thailand. It was revealed further that it is the fathers' professional occupations that positively influence students' achievement.

As expected, those students who found learning mathematics with ease (less anxiety) performed better in mathematics class. Although the effect is not as strong (b=0.88, p<.05) as the teacher-level factors, the effect, however, remains significant which may be contributed by the cross-level effect of MTOE. The cross-level interaction between MAS and MTOE is statistically significant (b=0.87, p<.05), which means that mathematics teachers belief (MTOE) had influenced the degree of relationship between MAS and mathematics achievement. This implies further that the higher the teacher's belief that their teaching skills and abilities and the efforts they put to facilitate students' learning will result into positive learning outcome, the stronger the effects of MAS will be on mathematics achievement.

Lastly, the EATP shows the strongest positive and direct effect on students' achievement (b=1.78, p<.05). This indicates that students achieve higher if they are given the opportunities to learn by themselves (independent learning) using enhanced activities in the classroom. This, however, does not imply that the more independent learning activities, the higher the performance. Likewise, this effect may differ by age, type of learners and availability of resources. Nevertheless, this result also reveals what the 21st century learners would prefer as an effective way of helping them learn and enhance their potentials. This likewise implicates on what mathematics teachers should focus in terms of their teaching and assessment practices. Educators and policymakers should likewise make this as a tool in revisiting and redesigning educational and curriculum policies in the mathematics classroom.

References

Ker, H. (2015). The impacts of student-, teacher-and school-level factors on mathematics achievement: an exploratory comparative investigation of Singaporean students and the USA students. *Educational Psychology*(ahead-of-print), 1-23.

Choi, N., & Chang, M. (2011). Interplay among school climate, gender, attitude toward mathematics and mathematics performance of Middle school students. *Middle Grades Research Journal, 6*(1), 15-28.

Demir, I., & Kilic, S. (2010). Using PISA 2003, examining the factors affecting students' mathematics achievement. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 38*(38).

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics, 100*(4), 194-202. doi: 10.1111/j.1949-8594.2000.tb17256.x

Ewumi, A. M. (2012). Gender and socio-economic status as correlates of students' academic achievement in senior secondary schools. *European Scientific Journal, 8*(4), 23-36.

Lockheed, M. E., Fuller, B., & Nyirongo, R. (1989). Family effects on students' achievement in Thailand and Malawi. *Sociology of Education*, 239-256.

Malik, R. H., Rizvi, A. A. (2018). Effect of classroom learning environment on students' academic achievement in mathematics at secondary level. *Bulletin of Education and Research, 40*(2), 207-218.

Osborne, J. W. (2000). Advantages of hierarchical linear modeling. *Practical Assessment, Research & Evaluation, 7*(1), 1-3.

Özdemir, N., Ayral, M., Fındık, L. Y., Ünlü, A., Özarslan, H., & Bozkurt, E. (2014). The relationship between students' socioeconomic status and their Turkish achievements. *Procedia-Social and Behavioral Sciences, 143*, 726-731. doi:10.1016/j.sbspro.2014.07.472

Peters, M.L. (2013). Examining the relationships among classroom climate, self-efficacy, and achievement in undergraduate mathematics: A multi-level analysis. International Journal of Science and Mathematics Education, 11(2), 459-480. doi: 10.1007/s10763-012-9347

Raudenbush, S., Bryk, A., & Congdon, R. (2005). HLM6: Hierarchical linear and nonlinear modeling (version 6)[Computer software]. Lincolnwood, IL: Scientific Software International, Inc.

Sheldon, S. B. & Epstein, J. L. (2005). Involvement counts: Family and community partnerships and mathematics achievement. *The Journal of Educational Research, 98*(4), 196-207. doi: 10.3200/JOER.98.4.196-207

Savaş, E., Taş, S., & Duru, A. (2010). Factors affecting students' achievement in mathematics. *Mathematics Learning*, 11(1).