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Do Teachers' Mathematical Knowledge for Teaching Matter on Pupils' Achievement?

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Abstract This study investigated the influence of teachers' Mathematical Knowledge for Teaching (MKT) on student's achievement. It employed survey method to gather data from fifty (50) elementary teachers and one thousand eight hundred thirteen (1,813) pupils of the Department of Education-Division of Iligan City during the school year 2019-2020. The researcher made use of two (3) instruments: Mathematics Teacher Questionnaire, 25-item MKT two-tiered test and 25-item researcher-made elementary mathematics achievement test. MKT test and researcher-made achievement test have reliability coefficients of .774 and .701 respectively. The analysis of the data gathered revealed that the mathematics teachers were poor in the MKT and has no significant relationship with pupil's mathematics achievement. Hence, the researchers recommend that educational leaders may redesign and reevaluate their in-service trainings to provide teachers with excellent professional development trainings, giving rewards and incentives to motivate teachers strengthen their subject content knowledge and appropriate pedagogy to improve student learning outcomes.

Keywords: *mathematical knowledge for teaching, pupils achievement, mathematics professional development, in-service training*

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1. Introduction

It is not surprising that young Filipino students have manifested poor mathematical skills. The report of the Programme for International Student Assessment (PISA) of the Organization for Economic Cooperation and Development (OECD) in 2018 stated that Filipino students performed poorly in both science and mathematics, landing almost at the bottom of the rankings.

Similarly, not only do teachers in the Philippines perform poorly in mathematics knowledge examinations, they also score low in tests that measure how well they can teach mathematics [1].

Recognizing the urgency of addressing the issues and gaps, the Department of Education (DepEd)-Philippines leads the national effort "Sulong Edukalidad" by implementing aggressive reforms on teachers upskilling and reskilling through a transformed professional development program in improving the delivery of quality teaching and learning of pupils in mathematics. It is a fact that teachers' mathematical knowledge of teaching (MKT) is very vital in concept knowledge formation because the children in the elementary schools the stage of developing minds on the basic concept knowledge necessary for critical thinking skill which is the ultimate goal of mathematics teaching [2]. This is an essential framework to pinpoint the need for DepEd to conduct in-depth needs-based Continuing Professional Development (CPD) program to address the critical and crucial concerns for improving mathematics achievement of pupils. Teachers play a critical role in developing the child skill of abstractions of mathematical concepts for successful learning.

This gap prompted the researcher to explore the influence of elementary teachers' mathematics knowledge for teaching on pupils' achievement. What do teachers need to know and be able to do to effectively carry out the work of teaching mathematics [3]? Identifying predictors of teacher knowledge could help district and school officials design training opportunities in content and pedagogy by formulating long term interventions that promote pupil's better performance in assessment [4].

With this end, the researchers employ MKT's model to provide empirical data on its influence on mathematics achievement. Specifically, this study investigated the effect of teachers' MKT on pupils' mathematics achievement.

Results of the study shall serve as the basis for designing needs-based Continuing Professional Development program (CPD) and Inservice trainings to improve teachers' MKT in the Department of Education-Division of Iligan City.

2. Method

2.1. Research Design

This study used the descriptive survey method of research. It examined the level of teachers' mathematical knowledge for teaching on the basic concept of mathematics and pupils' mathematics achievement on basic concepts of mathematics also. The survey was conducted one month after the start of academic year. The pupil's achievement test was administered after all the topics under study was covered.

2.2. Participants

The study was conducted at the Division of Iligan City - a government-owned clustered division of public schools located at the northern part of Mindanao. The respondents of this study consisted of 50 grade 6 teachers taken using simple random sampling technique from 58 elementary Mathematics teachers from the public schools during the school year 2019-2020. The researchers also randomly selected pupil-respondents that consisted of 1,813 pupils taught by the teacher-respondents. On the other hand, the respondents were assumed to bear similar characteristics in regional or ethnic groups as they are all Filipino by birth.

2.3. Research Instrument

In this study, there were 3 instruments used to gather the data. These are the Mathematics Teacher Questionnaire that is addressed to teachers of sixth-grade students and sought information about teachers' personal characteristics, a 25-item researcher-made mathematics achievement test was used to assess mathematical skills learned by the pupils. This instrument was subjected to content validity and reliability. At first, the researchers made 35-item multiple choice test on the basic concepts of mathematics based on the table of specifications (TOS). A panel of experts examined each item of this test for face and content validity. The experts made some corrections and suggestions. After which, the researchers modified the instrument and administered the revised test to the grade 7 of this same division. An item analysis was done and resulted with reliability coefficient of 0.701, and a 25-item adapted two-tiered MKT test on basic concepts of mathematics [5]. The first tier is multiple choice test about mathematics knowledge for teaching. The second tier is an open-ended question asking the respondents to explain their reasons and justify their answers in the first tier. This instrument undergone and passed through validity and reliability testing. It was shown to two master teachers in the field of mathematics, education program supervisors and to the adviser for corrections. Then, it was administered to the junior and senior high school teachers who were not participants of the study during the division-sanctioned 1 day conference. Before the validation, there were 35 items, but after the item analysis, 25 items passed the criteria with reliability coefficient of 0.774. A score of 1 point was given to the teachers with the correct answer in the first tier. Teachers' responses in the second tier were scored using the adapted holistic rubrics as shown below [6]:

Table 1. Scoring Rubric for MKT Second-tier Response

Score	Interpretation	Application	Explanation
3	Shows a superior understanding of the problem including the ability to identify the appropriate mathematical concepts and the information necessary for its solution must be complete and correct.	Uses a very efficient and sophisticated strategy leading directly to a solution Makes mathematically relevant observations and/or connections.	Clear, effective explanation detailing how the problem is solved; all the steps are included so that the reader does not need to ask how and why decisions were made Mathematical representation effectively used
2	Shows an adequate understanding of the problem and the major concepts necessary for its solution Addresses all of the components presented in the task. Solution must be complete and correct	Uses a strategy that leads to a solution of the problem Uses effective mathematical reasoning All parts are correct and a correct answer is achieved	Clear explanation given Appropriate use of accurate mathematical representation Appropriate use of mathematical terminology
1	Shows a partial understanding of the problem and the major concepts necessary for its solution Addresses some, but not all, of the mathematical components presented in the task Incomplete solution, indicating that parts of the problems are not understood	Uses a strategy that is partially useful, leading some way toward a solution, but not to a full solution of the problem Some evidence of mathematical reasoning Some parts may be correct, but a correct answer is not achieved	Incomplete explanation, may not be clearly presented Some use of appropriate mathematical representation Some use of mathematical terminology and notation appropriate to the problem

The average score the researcher and the two (2) raters were the final score of the respondents.

2.2. Data Collection

A division one-day conference was conducted one month after the beginning of the school year 2019-2020 to gather all the teacher-respondents to disseminate policy from DepEd and after the program the researcher administered the two (2) research instruments, the mathematics teacher questionnaire and MKT assessment. Respondents were given ample time to answer the set of questionnaires and requested to refrain from sharing their answers. Calculators and laptop with or without internet connections were not allowed. The pupils mathematics achievement test was administered to the randomly

selected pupil-respondents on the 24th week of the school year after the lessons were covered under study. The results of the MKT and achievement tests were recorded and analysis using descriptive statistics and correlation.

2.3 Data Analysis

To determine influence of teachers' MKT on pupils' mathematics achievement, the data were subjected to analyses. For descriptive analyses, the frequency, mean and standard deviation of the teachers' MKT and pupils' mathematics achievement were computed. The teachers' MKT mean scores were interpreted using the scale in Table 2.

Table 2. Rating Scale for Teachers' Level of MKT

Mean Score Range	Descriptive Level
90.0-100.0	Very Satisfactory
56.0-89.99	Satisfactory
25.0-55.99	Needs Improvement

Table 2 shows the rating score for teacher's level of mathematical knowledge for teaching. Below is the Table 3 for pupils' level of mathematics achievement, K-12 descriptive level was adopted.

Table 3. Rating Scale for Pupils' Level of Achievement

Mean Score Range	Descriptive Level
22.5- 25.0	Superior
18.75-22.49	Meeting the Standards
14.0-18.74	Nearly Meeting the Standards
8.75-13.99	Below the Standards
0-8.74	Poor

3. Results and Discussion

Table 4 shows the mean scores, standard deviation and descriptive levels of teachers' MKT and pupils' mathematics achievement on the basic concepts of mathematics.

Table 4. Mean, Standard Deviation and Descriptive Level of Teachers' MKT and Pupils' Mathematics Achievement Test Score

Type of Measure	n	Mean	SD	Level
Teachers' MKT	50	30.44	2.14	Needs Improvement
Pupils' Achievement	1,813	8.995	1.22	Below Standards

It can be noted that in Table 4 that teachers lack content and pedagogical knowledge in teaching and pupils were not meeting the standard learning as well. The MKT has shown a very low mean score of 30.44 out of 100 points with a standard deviation of 2.14. This indicates that the respondents had limited subject matter knowledge and pedagogical content knowledge on the basic concepts of mathematics and their scores are closed to each other. Furthermore, the achievement test scores of pupils have also a low mean score of 9.0 out of 25 points with a standard deviation of 1.22 which shows that pupils have homogenous scores which revealed that the teachers and pupils have similar results.

To determine if there is a significant relationship between teachers' MKT and pupils' achievement, the Pearson product-moment correlation techniques was used.

Table 5. Correlation between teachers' MKT and Pupils' Achievement

Variable	Correlation coefficient (r)	p-value
MKT	0.133	0.356
Achievement		

Not significance at 0.05.

Table 5 displays the summary correlation coefficient (r) between teachers' MKT and pupils' achievement. The results yielded that correlation coefficient (r) is equal to 0.133 with probability value of 0.356. This led the researchers to infer that pupils' low achievement reflect teachers low MKT. This means that teachers cannot share what they do not have.

This confirms the statements of the National Research Council and National Mathematics Advisory Panel and the findings of Jona Palmer, Ottomar, et. al., Yasmine Copur-Genturck and Aclan, et. al., Garet, et. al., Jami Garner and Aslam et. al that there were no direct or inverse relationship between mathematics knowledge of teaching to student achievement [7-13].

Although the findings of Heather Hill, Spyros Konstantopoulos, Madalina Tanase, Rockoff et. al. and Hill, et. al. revealed that MKT has modest to positive significant relationship with students' mathematics achievement but established with restrictions that it can affect more easily for grades 4 and younger students than in the case for older students [4,14,15,16,17]. It is important to study what factor might impact on student achievement especially in mathematics.

These results corroborate to the study of Judith Sowder that in order to increase mathematics knowledge and achievement, all mathematics classrooms require teachers with in-depth knowledge of mathematics [18].

4. Conclusions and Recommendations

Based on the findings of the study, the researchers concluded that Elementary mathematics teachers lack the necessary skills for teaching mathematics as reflected on their poor MKT results which reflects poor performance of pupils in the achievement test. Hence, teachers' mathematical knowledge for teaching has no influence to pupils' mathematics achievement. The researchers recommend that education leaders and school administrators should redesign and re-evaluate in-service trainings that provide teachers with good quality professional development program, give rewards and incentives to motivate and strengthen subject knowledge and teaching capabilities to enhance and improve student learning outcomes. In addition, create a lesson study group to help elementary teachers become more competent mathematics teachers.

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