Teachers' Pedagogical Knowledge and Mathematical Skills as Predictors of Students Achievement in the New Normal

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***Abstract*—** This research concentrates on the verification if there was a link between the pedagogical knowledge and mathematical skills to students' achievement in the new normal. This ex-post research looked into the relationship and predictive degree of teachers' pedagogical knowledge and mathematical skills to students' mathematical achievement. Teachers' pedagogical knowledge were found to be high in the study, whereas teachers' mathematical skills was found to be very high and the level of students' achievement in mathematics was also found as high. Both Teachers' pedagogical knowledge and mathematical skills does not have a significant impact to students' achievement in mathematics. The findings showed the importance of environmental context and appropriateness of online platforms in various strategies in improving student's mathematical achievement. The findings suggest that virtual platforms should be suitable to the instructional strategies and capabilities of teachers and the students. Environmental context also is very vital in this new normal setting of learning, especially in the provinces where internet connection is not stable in most of the places.

***Keywords*—** MAED-Teaching Mathematics, pedagogical knowledge, mathematical skills, math performance, Philippines.

I. INTRODUCTION

The low performance of students in mathematics is one of the serious problems in the academic sector in today's generation. The mathematics curriculum in the Philippines has been revised several times throughout the years. Despite the many changes to the curriculum, the goals of mathematics education remain more or less the same. Even though in its goal in providing opportunities in the development of skills in every learner, there are still struggles and challenges as to instilling it to them. According to the Programme for International Student Assessment, Filipino students earned an average of 353 points in Mathematical Literacy, much less than the OECD average of 489 points, and just one in every five Filipino students (19.7%) reached at least the minimal competency level (Level 2) in the same field. Furthermore, the Trends in International Mathematics and Science Study showed that the Philippines received just 297 points in mathematics and 249 points in science, which is "much lower" than the scores earned by any other participating nation. Additionally, the nation scored the lowest on both exams out of 58 participating countries. [38][46]

In addition, the level of students' achievement in mathematics is very important and should be immediately treated, because this result of the mathematical literacy of the Philippines might have a greater impact to the national progress. Maintaining the world's inventive edge requires, among other things, the development of a highly skilled workforce of scientists and engineers. To accomplish this goal, a system of education must create students with superior math and science abilities. An urgent need to improve educational quality has been shown by PISA 2018 findings. This compelled the execution of a modified professional development program for teachers and school administrators. [23][38]

The impact of the pedagogical knowledge of teachers to student's achievement in mathematics plays a significant role. It has been shown that students are more motivated and engaged when they are able to participate in cooperative learning activities. Cooperative learning practices are woven into many aspects of teachers' math standards. Teachers believe that student progress depends on a wide range of teaching strategies. It's not always best to choose one method over another; instead, consider the learning styles of your students and the subject matter you'll be covering. Moreover, High student-score improvements in math were achieved by using instructional approaches established on research and national standards, such as strengthening students' conceptual knowledge, giving greater covering of fewer mathematical ideas, and drawing links between math and other subjects. A better understanding of which standards and practices are related with higher student accomplishment may help school administrators pick resources and professional development activities, as

well as identify specific improvement areas for instructors with poor student achievement. [1][13]

Furthermore, high teacher effectiveness or mathematical skills has a direct impact on student achievement in mathematics. Numerous studies have shown a link between instructors' mathematical abilities and improved student performance. A low sense of self-efficacy may result in an unwillingness to undertake an activity again following a setback. Moreover, how the teachers view their performance affect how they deliver information to their students which is crucial in enhancing and developing students' performance. In this case, teachers should have high self-efficacy beliefs and little mathematics anxiety, as they are responsible for the early education of students. [7]

Thus, the researcher observed that although there are already studies conducted about the impacts of the pedagogical knowledge of teachers and their mathematical skills to the performance of the students, the researcher wants to conduct the study due to this new normal setting of learning which brings new challenges to teachers especially in instruction in the local environment. Most of the published studies either involved the pedagogical skills of teachers or teacher's mathematical skills as its independent variable. The focus of this study is to address and determine which domain in the teacher's pedagogical knowledge and mathematical skills predicts student's achievement in mathematics. Further study in the student's achievement in mathematics in this new way of learning could include the strength and weaknesses and the training needs of the teachers in adapting to this new way of learning. Math education and learning in the new normal are very difficult and complex. Uncertainties, concerns, and fears will abound. Misconceptions and animosity against the topic or instructor may develop. Therefore, the urgency to conduct the study is needed to help both learners and teachers enhance the curriculum in this new way of learning.

The main objective of this study is to determine which domain in teachers' pedagogical knowledge and mathematical skills significantly predicts achievement of BSEd – Mathematics students in Davao De Oro State College. Additionally, the study will seek to address the following objectives:

1. To assess the level of pedagogical knowledge of the mathematics teachers in Davao De Oro State College in terms of:
   1.1 Cooperative Learning
   1.2 Communication and study skills
   1.3 Technology-aided instruction
   1.4 Problem-based learning
   1.5 Direct instruction
2. To assess the level of teachers' mathematical skills in teaching mathematics in Davao De Oro State College in terms of:
   2.1 Efficacy for Pedagogy in Mathematics (EPM)
   2.2 Efficacy for Teaching Mathematics Content (ETCM)
3. To describe the level of students' achievement of BSEd – Mathematics majors in Davao De Oro State College.
4. To determine the significant relationship between:
   4.1 Teachers' pedagogical knowledge and students' achievement; and
   4.2 Teachers' mathematical skills and students' achievement among BSEd – Math majors in Davao De Oro State College.
5. To determine which domains of pedagogical knowledge and mathematical skills of mathematics teachers significantly predict the level of achievement of BSED-Mathematics students in Davao De Oro State College.

II. METHODOLOGY

This research study will use a multiple linear regression quantitative research design to investigate the relationships between the predictor variables of Teachers' Pedagogical Knowledge which will be measured by the TIPS that is designed by Haas [22], Teachers' Mathematical Skills which will be measured by the SETMI that is designed by McGee [32] and the criterion variable of students' achievement as measured by the mathematics grades of students in state colleges of Davao De Oro.

The quantitative technique was adopted for this study because it was necessary to measure numeric factors in order to determine if teachers' pedagogical knowledge and mathematical skills are predictive of student mathematical achievement in this new normal environment. Correlational design was adopted because it enabled the examination of relationships between variables without manipulating them and the evaluation of predictor variables' predictive value on a criterion variable. A correlative approach was justified in this study because the objective was to ascertain the complex relationship between variables and to ascertain the existence of a relationship between the predictor variables (teachers' pedagogical knowledge and teachers' mathematical skills) and the criterion variable (mathematics achievement). Additionally, a correlative technique allowed for the identification of the predictor variable's relationship to the criteria variable, as well as its effect on the criterion variable.

The sampling technique that was used in the study is stratified random sampling since Davao De Oro State College has four campuses and proportional representations will be done on each group in the population. There was a total of 462 populations who were considered as respondents and were students who are enrolled in Bachelor of Secondary Education major in Mathematics. The number of samples per campus were identified through the use of Slovin's Formula.

The respondents are composed of Bachelor of Secondary Major in Mathematics students for the evaluation of their teachers' pedagogical knowledge and mathematical skills and the measurement of learners' achievement will be measured through the average grades in mathematics of BSED – Mathematics students. The participants that will be involved in the conduct of the study will be the Bachelor of Secondary Education Major in Mathematics Students in Davao De Oro State College. On the other side, individuals who are not included in the study's conduct will be those who do not major in mathematics. Other schools in the province of Davao De Oro are not included in the identification of samples in this study because Davao De Oro State College is the only state college in the province. Moreover, participants are allowed to discontinue his or her participation in the study if he or she feels uncomfortable or to what reason/s (not required to provide reason) he/she may have in withdrawing from the study.

III. RESULTS AND ANALYSIS

Descriptive Analysis on Teachers' Pedagogical Knowledge, Teachers' Mathematical Skills, and Students' Achievement

The teachers' pedagogical knowledge with a mean of 4.17 labeled as high and a 0.59 standard deviation, were presented in Table 1. The high score is likely due to respondents' strong ratings for all indicators in terms of *cooperative learning, communication and study skills, technology-aided learning, problem-based learning and direct instruction.* The overall mean score referred to was the result of the following computations of the mean scores from greatest to lowest indications: 4.25 and 0.60 or very high for *communication and study skills*; 4.24 and 0.70 or very high for *technology-aided learning*; 4.16 and 0.66 or high for *problem-based learning*; 4.10 and 0.65 or high for *cooperative learning*; and, 4.09 and 0.71 or high for *direct instruction.*

It was found out that the level of teachers' pedagogical knowledge of the campuses of Davao De Oro State College was high. This is because of the high rating assumed by the respondents in terms of cooperative learning, communication and study skills, technology aided learning, problem-based learning, and direct instruction, which means that the level of teachers' pedagogical knowledge in new normal setting was much observed. It means that the teachers encouraging students to inquire when they encounter challenges or misconceptions, allow students use calculators for computations, draw mathematical concepts from "real-life" situations, allow students to engage in cooperative problem solving, and ensure that the majority of the problems review previously covered material when assigning practice work.

Table 1. *Level of Teachers' Pedagogical Knowledge*

Indicator	Mean	SD	Descriptive Equivalent
Cooperative Learning	4.10	0.65	High
Communication and Study Skills	4.25	0.60	Very High
Technology-Aided Learning	4.24	0.70	Very High
Problem-Based Learning	4.16	0.66	High
Direct Instruction	4.09	0.71	High
Overall	**4.17**	**0.59**	**High**

The teachers' mathematical skills with a mean of 4.22 labeled as very high and 0.64 standard deviation, were presented in Table 2. The high score is likely due to respondents' strong ratings for all indicators in terms of *efficacy for pedagogy in mathematics,* and *efficacy for teaching mathematics content.* The overall mean score referred to was the result of the following computations of the mean scores from greatest to lowest indications: 4.22 and 0.68 or very high for *efficacy for pedagogy in mathematics;* 4.22 and 0.64 or very high for *efficacy for teaching mathematics content.*

It was found out that the level of teachers' mathematical skills in Davao De Oro State College campuses was very high. This is because of the high rating assumed by the respondents in terms of the efficacy for pedagogy in mathematics and efficacy for teaching mathematics content, which means that the level of teachers' mathematical skills was very much observed. It means that the teachers are very well in helping students give value in learning mathematics and well enough in teaching students to explain the goals of the teaching of mathematics.

Table 2. *Level of Teachers' Mathematical Skills*

Indicator	Mean	SD	Descriptive Equivalent

Efficacy for Pedagogy in Mathematics	4.22	0.68	Very High
Efficacy for Teaching Mathematics Content	4.22	0.64	Very High
Overall	**4.22**	**0.64**	**Very High**

The students' achievement is defined as the average grade of the students in mathematics subject. The grades mentioned was the performance of the students for a semester. The mean score or the average grade, the standard deviation and the description for the dependent variable were presented in Table 3. The high mean score for the level of students' achievement can be attributed to the high performance of students to the subject.

Table 3. *Level of Students' Achievement*

Indicator	Range	Mean	SD	Descriptive Equivalent
Average Grade in Mathematics	85.00 to 96.00	89.91	2.78	High

The table above reveal that the level of students' achievement specifically in mathematics was described as high. It also tells that the overall mean was 89.91 which is the result of the average grade of students in mathematics and it means that the students' performance in mathematics was above average. The table also included the standard deviation which 2.78 that indicates high dispersion of data. It means that there is a great difference between the highest and the lowest grade of students in mathematics in relation to the mean score.

Correlation Analysis on Teachers' Pedagogical Knowledge and Students' Achievement

Table 4 shows the relationship between the indicators for the independent variable, *teachers' pedagogical knowledge* which are the *cooperative learning, communication and study skills, technology aided learning, problem-based learning, and direct instruction* to the *students' achievement in mathematics.* The first indicator has a 0.055^{*} r-value and a 0.426 p-value which tells that there is no significant relationship and a coefficient of determination of 0.003, which shows a negligible correlation. The second indicator has a 0.051^{*} r-value and a 0.458 p-value which tells that there is no significant relationship and a coefficient of determination of 0.0026, which shows a negligible correlation. The third indicator has a 0.029^{*} r-value and a 0.671 p-value which tells that there is no significant relationship and a coefficient of determination of 0.0008, which shows a negligible correlation. The fourth indicator has a 0.063^{*} r-value and a 0.358 p-value which tells that there is no significant relationship and a coefficient of determination of 0.0040, which shows a negligible correlation. For the last indicator, it has a -0.025^{*} r-value and a 0.713 p-value which tells that there is no significant relationship and a coefficient of determination of 0.0006, which shows a negligible correlation.

Correlation Analysis on Teachers' Mathematical Skills and Students' Achievement

Table 5 shows the relationship between the indicators for the independent variable, *teachers' mathematical skills* which are the *efficacy for pedagogy in mathematics* and *efficacy for teaching mathematics content.* The first indicator has a 0.073^{*} r-value and a 0.284 p-value which tells that there is no significant relationship and a coefficient of determination of 0.0053, which shows a negligible correlation. The second indicator has a 0.032^{*} r-value and a 0.643 p-value which tells that there is no significant relationship and a coefficient of determination of 0.0010, which shows a negligible correlation.

Correlation Analysis on the Relationship between Teachers' Pedagogical Skills and Teachers' Mathematical Skills to Students' Achievement

Table 6 shows that the hypothesis that there is no significant relationship between teachers' pedagogical knowledge and teachers' mathematical skills to students' achievement in mathematics is not rejected. This result tells that there is no need to proceed for the identification of significant predictors, since there is no significant relationship existed between the variables.

Table 4. *Significance on the Relationship between Teachers' Pedagogical Knowledge and Students' Achievement*

Independent Variable (Indicator)	Dependent Variable	r-value	r-square	p-value	Decision
Cooperative Learning	Students' Achievement	0.055^{*}	0.0030	0.426	H_o is not rejected
Communication and Study Skills		0.051^{*}	0.0026	0.458	H_o is not rejected
Technology Aided Learning		0.029^{*}	0.0008	0.671	H_o is not rejected
Problem-Based Learning		0.063^{*}	0.0040	0.358	H_o is not rejected

Direct Instruction		-0.025*	0.0006	0.713	H_o is not rejected

*Significant at 0.05 level of significance

Table 5. *Significance on the Relationship between Teachers' Mathematical Skills and Students' Achievement*

Independent Variable (Indicator)	Dependent Variable	r-value	r-square	p-value	Decision
Efficacy for Pedagogy in Mathematics	Students' Achievement	0.073*	0.0053	0.284	H_o is not rejected
Efficacy for Teaching Mathematics Content		0.032*	0.0010	0.643	H_o is not rejected

*Significant at 0.05 level of significance

Table 6. *Significance on the Relationship between Teachers' Pedagogical Skills and Teachers' Mathematical Skills to Students' Achievement*

Independent Variable	Dependent Variable	r-value	r-square	p-value	Decision
Teachers' Pedagogical Skills	Students' Achievement	0.038*	0.0014	0.584	H_o is not rejected
Teachers' Mathematical Skills		0.055*	0.0030	0.423	H_o is not rejected

Regression Analysis on Teachers' Pedagogical Knowledge and Teachers' Mathematical Skills as Predictors of Students' Achievement in Mathematics

The results of this study showed that there are no significant relationships between the variables, which are the *teachers' pedagogical knowledge* and *teachers' mathematical skills* to *students' achievement*. This leads the researcher to do not proceed to regression analysis since there are no significant relationship among the variables. This is aligned to the assumptions in regression analysis that before we proceed in regression analysis, we should consider the five assumptions, namely; *linear relationship*, *multivariate normality*, *no or little multicollinearity*, *no auto-correlation*, and *homoscedasticity*.

IV. CONCLUSION

Returning to the research aims' outcomes, the researcher concluded that the level of teachers' pedagogical knowledge in new normal was high. While the level of teachers' mathematical skills in new normal was very high. The level of students' achievement in mathematics was high as well the same with the pedagogical knowledge of teachers. For the significant relationship between variables, it was found out that the level of teachers' pedagogical knowledge has an insignificant relationship to the level of students' achievement in mathematics.

Also, the researcher found out that the level of teachers' mathematical skills has an insignificant relationship to students' achievement in mathematics as well.

Additionally, virtual instruction as a mode of instruction is a relatively recent concept. Having said that, instructors might push themselves to investigate successful techniques for promoting and managing small group work. Students need possibilities for social contact through online technologies in order to continue exploring and discussing mathematics in the same way they did during face-to-face training. Although virtual mathematics training may seem to be different from face-to-face instruction, the results and students' mathematical comprehension should be same.

Following a thorough examination of the study's findings and conclusion, the researcher made various recommendations regarding how students might enhance their performance in mathematics.

First, to raise the level of teachers' pedagogical knowledge in this online learning to very high, teachers should be engaged to different professional development that talks about the proper utilization of different instructional practices. Teachers should also consider learning developments that is all about exploring and understanding different virtual platforms in learning, specifically on its appropriateness to different instructional strategies. Moreover, in this new normal setting or new way of learning teachers should consider to ensure that the majority of the problems, review previously covered material when assigning practice work. Since this is because direct instruction got the lowest mean score among other indicators. In addition, school heads should also provide proper assessment to the instructional materials and online platforms that will be used during instruction.

Second, to maintain the level teachers' mathematical skills in this online learning which is very high, teachers should engage also their selves to advance concept in mathematics so that they can understand better each principle that will be encountered and also always update their selves to new trends in dealing with students to be more efficient in terms of pedagogy in mathematics. Precisely, to help students give value in learning mathematics. School administrators also can provide activities that allows the teachers to exercise their mathematical skills, like letting the teachers conduct webinars about teachers' mathematical skills specifically in efficacy for pedagogy in mathematics and efficacy for teaching mathematics content.

Third, to raise the level of students' achievement in mathematics in this online learning to very high, teachers should have an information to the different backgrounds of the students not just their previous academic performance. But also, their current economic status which is not limited to the identification if they can access the internet or not. Moreover, teachers should also know what specific environment these students have. With this, teachers can properly decide to what specific strategies he/she may apply in order improve the student's performance in dealing mathematics. The institution should provide also budgetary allocation or look for means in order to have a more reliable internet connection not just for the teachers but also for the students, because no matter how high the pedagogical knowledge and mathematical skills of the teachers if students doesn't have enough learning resources especially in the context of Davao De Oro State College, learning will still be difficult for the students. The very dispersed average grades of students maybe because some of them are not provided or cannot have enough learning references to understand better the topics.

Lastly, the researcher recommended to provide orientations or webinars to the students in terms of utilizing different virtual platforms or tools that are relevant in understanding mathematics in this new way of learning. Furthermore, the researcher recommended to look for other factors that significantly impacts and predicts the achievement of students in mathematics. Also, the researcher appreciates other researches that talks about the reason of insignificance between the variables, specifically knowing the perceptions of students to this new way of learning in different context.

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