MEDIATING ROLE OF MATHEMATICS TEACHING EFFICACY ON THE RELATIONSHIP BETWEEN PEDAGOGICAL CONTENT KNOWLEDGE AND MATHEMATICS TEACHING ANXIETY

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ABSTRACT

Effective education requires teaching efficacy, teaching anxiety, and teaching knowledge, all of which are essential elements. In-service mathematics teachers in the province of Quezon participated in this study to examine the role of mathematics teaching efficacy (MTE) as a mediator in the link between pedagogical content knowledge (PCK) and mathematics teaching anxiety (MTA). 200 in-service mathematics teachers from the Division of Quezon participated in the study by completing a set of questionnaires that included the MTE Scale, MTA Scale, and PCK Scale. The study utilized a quantitative descriptive research design and a mediation analysis. As the main objectives of the study were identified through the problem statement, the researcher decided to adopt the research design as a tool that carried out the study and served as the blueprint to guide the study accordingly. The PROCESS macro was used to conduct mediation analysis to test the theoretical hypothesis. It was found that MTE performs a competitive complete moderating function in the association between PCK and MTA for in-service teachers. The statistics show that high PCK improves in-service teachers' MTE while decreasing their MTA. Even though PCK predicts MTE, which predicts MTA in turn, further longitudinal and experimental investigations are required to fully comprehend this progression. MTE thus acts as a mediator in the connection between the PCK and MTA.

Keywords: mathematics teaching anxiety, mathematics teaching efficacy, pedagogical content knowledge, mediation analysis via the process macro

INTRODUCTION

Effective teaching is the knowledge, approaches, procedures, and behaviors that result in positive student performance. Effective teachers use their knowledge to improve their student's learning and have a positive influence on them. However, keep in mind that not all components of good teaching are immediately visible or measurable.

Effective teachers establish strong working connections with their students in situations that are both safe and courteous. Effective teaching is much more than end-of-year data: it is a continuous, reflective activity that must be modified and adjusted to meet the needs of students. Effective teachers develop effective learners who actively participate in their own learning and personal growth. They may manage a classroom to eliminate or lessen challenging behavior, provide new knowledge in an engaging and accessible manner, and engage students' interest in the subject matter to improve higher-order thinking. Effective teachers are passionate about their topic and use their expertise and pedagogical skills to create high-quality learning environments. Mathematics is the foundation of knowledge in a wide range of scientific disciplines. This area of

study is based on a cumulative understanding of mathematics rather than a set of organized concepts. Students should be able to build this expanding structure outside of the theoretical framework of the classroom as part of their mathematics education. In this regard, mathematics education has been one of the most complicated and quickly evolving study topics, with various theoretical methods created. (Goos & Bennison, 2018; Zevenbergen, 2005). With a framework he calls pedagogical content knowledge (PCK), Lee Shulman introduced a new method of considering the knowledge that teachers must impart to their students. This way of thinking combines pedagogical knowledge, which includes general teaching and learning knowledge, with content information, the main resource teachers need to teach. The technique for presenting and constructing the knowledge that helps students understand the subject is called PCK, which is the intersection of these two sets of knowledge. Lee Shulman presented a novel approach and a hypothetical set of domains of teacher expertise. Shulman argued that the investigation of "teachers' cognitive understanding of subject matter content and the relationships between such understanding and the instruction teachers provide for students" may be the "missing program" in educational research as a response to the overabundance of generic educational research. The three categories of content understanding—subject matter knowledge, pedagogical knowledge, and curricular knowledge—and their effects on classroom practice were then differentiated and called for. The constructs were renamed subject matter knowledge, curricular knowledge, and pedagogical content knowledge in later model revisions. Of them, the "subject matter for teaching" known as pedagogical content knowledge has attracted a lot of attention in both the research and practice worlds. According to Shulman, pedagogical content knowledge (PCK) is the method of presenting and constructing a subject that enables others to understand it. The description of PCK and its position within the constellation of knowledge categories for teaching are all covered in several papers by Shulman and his colleagues. They also present changing views of the domains of teacher knowledge. Researchers and teacher educators have created a variety of approaches and techniques to examine pedagogical topic knowledge, including paper and pencil tests (particularly multiple-choice exams), concept maps, visual representations, interviews, and multi-method evaluations. These methods have been applied to staff development, program development, and teacher assessment, among other objectives.

However, we also refer to research from other disciplines that may help consider how pedagogical content knowledge might inform teaching in mathematics. The main emphasis will be on studies of pedagogical content knowledge that concentrate on the teaching of mathematics.

Eleonor (2014) identified several challenges to raise various issues that are relevant to the study of pedagogical topic knowledge, including difficulties in evaluating teacher cognition. First, it is impossible to directly observe pedagogical content understanding. A teacher's understanding of the examples from their subject area that best illustrate themes and their awareness of the typical student struggles related to those issues make up their pedagogical content knowledge, which is partly an internal construct. Mathematics is a subject that is taught from elementary school through college, but many students find it intimidating and challenging to understand. Many learners experience anxiety each time they study mathematics because of these anxieties. Mathematical anxiety is characterized by stress and worry that impairs the ability to manipulate numbers and solve mathematical puzzles in a variety of real-world and academic contexts. Mathematics can cause tension, anxiety, and panic in people who have a high level of math anxiety. It has been repeatedly shown that mathematics anxiety negatively affects math performance. According to research, it is a taught behavior that frequently appears early in a person's scholastic career and, once it takes root, its detrimental impacts will persist throughout the school years. However, because most studies are carried out in the United States, there is a lack of information on students from Asia. Furthermore, as opposed to kids in lower grades, most researchers had experience working with high school or college students.

In addition to teaching rigidly, emphasizing rote learning and teaching, spending less time responding to students' queries, and not using open questions, teachers who are worried about mathematics are also observed to teach rigorously. However, not only inexperienced teachers but also seasoned teachers occasionally suffer similar anxiousness. Regular users of mathematics are also more likely to experience mathematical anxiety, which can lead to decreased productivity in their area of expertise. These teachers' nervousness not only makes studying more difficult, but it also has an impact on the pupils they are instructing because good teachers can help their students learn more effectively. Learning material is one of the most crucial things that needs to be prepared before teaching in a class. The primary component that shapes the learning process's content is the learning material. Naturally, the material that needs to be mastered to teach mathematics is mathematical stuff. Mathematical content is renowned for being challenging to comprehend. To make mathematics more difficult, several mathematical components are connected. Various prerequisites must be learned to comprehend the topic. This creates some material that inexperienced teachers haven't yet mastered, which fuels their nervousness when teaching math.

Anxiety is a normal emotion that everyone encounters. However, worry can be quite upsetting for someone's situation. The performance of anyone, including a teacher, can be impacted by this unsettling uneasiness. Anxiety related to teaching mathematics is one type of anxiety that might impair a teacher's performance. Anxiety while teaching mathematics refers to a state of worry or anxiety during the teaching of mathematical concepts to students. New teachers may experience anxiety for several reasons. These elements may originate inside or outside the teacher. This concern is typically brought on by a failure to demonstrate mastery of the expected teacher competencies. Pedagogical competence, personality competence, social competence, and professional competence are all part of the teaching competencies. In this regard, this study aims to understand the mediating role of mathematics teaching efficacy on the relationships between pedagogical content knowledge and mathematics teaching anxiety. This will be useful to have a greater understanding of the context of mathematics teaching and how this brings a negative implication in the mental health aspect of the teachers.

OBJECTIVES OF THE STUDY

This study determined the mediating role of mathematics teaching efficacy on the relationship between pedagogical content knowledge and mathematics teaching anxiety of the Mathematics Teachers in the Division of Quezon. Specifically, it sought to 1) determine the level of pedagogical content knowledge of the respondents in mathematics; 2) assess the level of the respondents' mathematics teaching anxiety 3) determine the level of mathematics teaching efficacy of the respondents; and 4) determine if mathematics teaching efficacy mediates the relationship between pedagogical content knowledge and mathematics teaching anxiety.

METHODOLOGY

The study utilized a quantitative descriptive research design and a mediation analysis. As the main objectives of the study were identified through the problem statement, the researcher decided to adopt the research design as a tool that carried out the study. This descriptive research used survey questionnaires with a structured and outlined set of items to quantify the responses. Being the most adopted design, it emphasized harvesting of first-hand data which is analyzed and interpreted to generate useful information out of the unstructured data. The researcher significantly used this method for this research study that dealt with an investigation and description of a phenomenon in a specific population. Researchers utilized surveys to sample a wide number of users to gather indirect quantitative, bias-free data on users in relevant scenarios. The data was gathered and subjected to statistical analysis. The data from the profile was

tallied, analyzed, and interpreted using weighted mean and frequency counts. Moreover, the researcher used the Pearson Product Moment Coefficient of correlation r to determine the degree of relationship found in the hypotheses.

To discover fundamental statistical values and correlations between variables, descriptive statistics, and correlation analysis were applied. The PROCESS macro, created by Andrew Hayes, is one such instrument. The PROCESS macro computes regression analyses with the mediator. The mediating function of MTE in the link between PCK and MTA was identified using Process Macro. The association between PCK and MTA, PCK and MTE, and MTE and MTA were established first using simple regression analyses. Since in each instance of simple regression analyses, significant effects were found between the variables, then mediation analyses using the PROCESS MACRO were conducted. The measurement model that dealt with the link knowledge of the subject curriculum, knowledge of assessment, and knowledge of the student's subject area are all included in their concept of pedagogical content knowledge.

RESULTS AND DISCUSSION

1. Level of Pedagogical Content Knowledge

The results for Pedagogical Content Knowledge revealed that the teachers had a favorable perception of their PCK level. They agreed that they ought to be knowledgeable enough about the material about the competencies they were instructing. They agreed that the ways they use to teach math have a sufficient structure to help students learn more and perform better on math tests. Additionally, the overall mean of 4.36 shows that the majority of teachers agreed with the claims made on the degree of PCK. The standard deviation of 0.46 suggests that the responses were generally consistent and that the majority of the teachers held the same views.

Table 1

Mean Distribution of the Respondents as to Pedagogical Content of Knowledge

Level of Pedagogical Knowledge	Mean	Std. Deviation	Verbal Interpretation
PCK1	4.47	0.56	Strongly Agree
PCK2	4.37	0.59	Strongly Agree
PCK3	4.38	0.53	Strongly Agree
PCK4	4.46	0.50	Strongly Agree
PCK5	4.39	0.65	Strongly Agree
PCK6	4.33	0.63	Strongly Agree
PCK7	4.36	0.53	Strongly Agree
PCK8	4.30	0.70	Strongly Agree
PCK9	4.41	0.59	Strongly Agree
PCK10	4.11	0.64	Agree
Mean	**4.36**	**0.46**	**Strongly Agree**

The teachers' high PCK was evidently visible in the result because they know the curriculum wherein, they can easily diagnose and eliminates student's difficulties and misconceptions through giving formative assessments that they can identify the competencies they should address more in their instruction through Item Analysis that they conducted quarterly. They stimulate conversation about the error by asking questions like "How did you come up with that answer and why do you think it's correct? " and emphasis on having the student clarify their thinking.". This makes it evident whether the mistake was the result of a simple "slip of the mind" or misunderstandings. Additionally, they have a variety of methods for addressing these issues and misunderstandings, including the use of illustrations, practical exercises, and idea-sharing sessions. They have a budget for work to complete and a curriculum plan to follow, which

allows them to connect their teaching pace with the quarterly competencies.

It indicates that teachers are better equipped to address students' difficulties in mathematics when they can work effectively independently. Additionally, they can employ a variety of techniques and interventions to help the understanding and knowledge of instruction strategies (Magnusson, Krajcik and Borko, 2013).

The PCK approach, which emphasizes that pedagogical content knowledge is created through the transformation of other domain knowledge, is supported by these findings. The teacher's orientation to teaching the subject,

Furthermore, there are four central components to pedagogical content knowledge: knowledge and beliefs about purpose, knowledge of student conceptions, curricula knowledge, and knowledge of instructional strategies (Francisco, 2015). As Appleton (2013) points out, most of the work on pedagogical content knowledge has been undertaken at the secondary school level in particular subject areas. Pedagogical content knowledge (PCK) refers to concepts, procedures, misconceptions, types of understanding, mastery assessment techniques, and conceptual understanding (Aoibhinn, 2016).

2. Level of Mathematics Teaching Anxiety

Most indicators were assessed to be "Often" with an overall mean of 3.58 with a standard deviation of 0.46 indicates a relatively high level of variability in the scores meaning that the teachers' responses were consistent. The verbal interpretation of the mean score generally "often" implies that the teachers assessed the MTA was visible in their instruction.

Furthermore, most of the indicators were assessed "often" because those circumstances were present in their classes. It implies that the students who don't follow the requirements of teachers possess. The effectiveness of a teacher's instruction directly affects the math achievement of their students. Moreover, using various methods and techniques, math teachers discover better ways to teach mathematics.

Table 2

Mean Distribution of the Respondents as to Mathematics Teaching Anxiety

Level of Mathematics Teaching Anxiety	Mean	Std. Deviation	Verbal Interpretation
MTA1	4.16	0.90	Often
MTA2	4.12	0.93	Often
MTA3	4.22	0.83	Always
MTA4	4.10	0.90	Often
MTA5	4.40	0.77	Always
MTA6	3.98	0.86	Often
MTA7	3.68	1.05	Often
MTA8	4.80	0.51	Always
MTA9	3.15	1.07	Sometimes
MTA10	2.71	1.34	Sometimes
MTA11	3.07	1.07	Sometimes
MTA12	2.73	1.24	Sometimes
MTA13	2.77	1.16	Sometimes
MTA14	3.04	1.10	Sometimes
MTA15	2.72	1.23	Sometimes
MTA16	3.68	1.08	Often
Mean	**3.58**	**0.68**	**Often**

The mathematics curriculum is the source of the teacher's anxiety during class. Additionally, when students struggle with the lesson, when they show a lack of enthusiasm for the subject, when they aren't paying attention in class, and when they don't understand mathematical concepts, it can cause anxiousness in the teacher. They get anxious when their students don't meet the curriculum standards which leads to their failed assessment. As they identify the difficulties and misconceptions of the students, they will teach the lesson repetitively.

Nowadays, different factors affect MTA such as the learning gaps caused by the pandemic. Teachers couldn't cope with some students having difficulty in Mathematics like the Grade 7 students, they weren't able to recite the multiplication table properly, they don't know different kinds of

polygons and most especially they weren't able to solve a simple problem involving integers with positive and negative signs.

3. Level of Mathematics Teaching Efficacy

The overall mean of 4.33 implies agreement in all the statements about feedback in the MTE. The standard deviation for all the indicators is relatively consistent. It means that there are similar views among the teachers.

Table 3

Mean Distribution of the Respondents as to Mathematics Teaching Efficacy

Level of Mathematics Teaching Efficacy	Mean	Std. Deviation	Verbal Interpretation
MTE1	4.56	0.55	Strongly Agree
MTE2	4.63	0.53	Strongly Agree
MTE3	4.43	0.65	Strongly Agree
MTE4	4.65	0.48	Strongly Agree
MTE5	4.50	0.64	Strongly Agree
MTE6	3.69	1.02	Agree
MTE7	4.48	0.53	Strongly Agree
MTE8	4.30	0.71	Strongly Agree
MTE9	4.12	0.79	Agree
MTE0	3.62	1.20	Agree
MTE11	4.72	0.45	Strongly Agree
Mean	4.33	0.46	Strongly Agree

Based on the data, teachers generally perceived MTE positively. Furthermore, it implies that the success of students in mathematics is often the responsibility of the mathematics teacher. Additionally, effective teaching is a skill that math teachers possess. The effectiveness of a teacher's instruction directly affects the math achievement of their students. Moreover, using various methods and techniques, math teachers discover better ways to teach mathematics.

Furthermore, it was evidently shown that students' performance was the basis of teachers' effectiveness. In this case, teachers tend to find better techniques to teach mathematics effectively. On the other hand, they thought that if the students were underachieving in Mathematics, it is mostly due to the inefficacy of the teacher because some of them find it difficult to use the software and applications to explain to the students why Mathematics works. One factor of the teachers' failure in using those is negligence and inexperience because some don't have the gadgets to use, and some don't know how to use them.

Finally, as the teachers provided feedback, it became clear that they were well-prepared, fair in their expectations, upbeat, and patient with the students. They also regularly evaluated their teaching. They make certain that pupils receive the greatest results possible.

According to Luttenberger et al. (2018), math self-efficacy refers to a person's perception of their aptitude for solving certain mathematical issues, carrying out mathematical tasks, and doing well in courses connected to mathematics. In the context of learning math, the concept of math self-efficacy is very crucial. According to research (Martin & Rimm-Kaufman, 2015), children who enter school with high internal resources (such as self-efficacy) can engage in more mathematical learning and are better "equipped" to handle the obstacles of the subject.

According to recent research, increasing students' math self-efficacy may also help them feel less anxious about arithmetic (Rozgonjuk et al., 2020).

4. Mediation Analysis of Mathematics Teaching Efficacy on the Relationship Between Pedagogical Content Knowledge and Mathematics Teaching Anxiety

The total effect showed a significant impact of mathematics teaching efficacy on pedagogical content knowledge and a significant impact of mathematics teaching efficacy on mathematics teaching anxiety.

Table 4

Mathematics Teaching Efficacy Mediate the Relationship between Pedagogical Content Knowledge and Mathematics Teaching Anxiety

	B	SE	t	P	LLCI	ULCI		
PCK → MTE	0.616	0.05	11.2125	.000	0.507	0.724	Significant	
MTE → MTA	0.748	0.12	6.1004	.000	0.506	0.989	Significant	
PCK → MTA	-0.232	0.12	-1.912	.057	-0.471	0.007	Not Significant	
Direct	-0.232	0.12	-1.912	.057	-0.471	0.007	Not Significant	Competitive Full Mediation
Indirect	0.461	0.09			0.299	0.433	Significant	
Total	0.229	0.55	11.213	.000	0.508	0.743	Significant	
PCK → MTE	0.616	0.05	11.2125	.000	0.507	0.724	Significant	
MTE → MTA	0.748	0.12	6.1004	.000	0.506	0.989	Significant	

A mediation analysis using Process Macro was undertaken to investigate the model outlined in Table 4 in which MTE was proposed to mediate the relationship between PCK and MTA. The mediation analysis was a very good fit to data across the different fit indices. It indicates that the direct model (linking pedagogical content knowledge to mathematics teaching anxiety) was not statistically significant ($\beta = -0.232$, $p > 0.05$). Moreover, the full mediation model (linking pedagogical content knowledge through mathematics teaching efficacy) had a significant effect ($\beta = 0.616$, $p < 0.05$). Furthermore, the full mediation model (linking mathematics teaching anxiety through mathematics teaching efficacy) had a significant effect ($\beta = 0.748$, $p < 0.05$).

According to the correlation coefficients, there was a competitive full mediation in which mathematics teaching efficacy mediated the pedagogical content knowledge and mathematics teaching anxiety. It has been revealed that mathematics teaching efficacy has a significant effect on pedagogical content knowledge and mathematics teaching anxiety.

Considering this, the connection between PCK and MTE can be interpreted as being dependent on how well teachers can use MTE in classroom settings. PCK consequently raises MTE. Due to the robust pedagogical content, teachers with high mathematics teaching efficacy are better able to carry out correct and efficient mathematics teaching.

Furthermore, this study indicates that MTA is positively associated with MTE. It implies that teachers with a high level of MTE decrease their MTA. Teachers can learn mathematical concepts or how to teach mathematics effectively. Furthermore, MTE and MTA are relatively significant to each other because MTE affects the MTA wherein if the teacher is well-versed there is also a high level of MTA. After all, if the teacher is anxious, they mind doing better. They have the mindset of "cramming works" because they can be able to think of better ways if they feel anxious.

If the teacher has a higher PCK it lowers MTA it is because of the teacher's efficaciousness. Therefore, teachers must focus on their self-efficacy in teaching so that they can balance the level of their PCK and MTA. This logical and theoretical framework can be used to explain MTE's mediating role in the relationship between PCK and MTA.

CONCLUSIONS

This study was designed to determine whether mathematics teaching efficacy mediates the relationship between pedagogical content knowledge and mathematics teaching anxiety. The study yielded the following findings:

1. There is a high level of pedagogical content knowledge from the teachers.
2. Teachers experienced teaching anxiety during instruction.
3. Teachers assessed themselves as efficacious teachers.
4. There is a competitive full mediation of mathematics teaching efficacy towards pedagogical content knowledge and mathematics teaching anxiety. Thus, mathematics teaching efficacy mediates the relationship between pedagogical content knowledge and mathematics teaching anxiety.

RECOMMENDATIONS

Based on the conclusions formulated from the findings, the following recommendations are given.

1. Education Program Supervisor in Mathematics may expose the teachers to educational research that could support them in expanding their PCK. Furthermore, teachers should integrate their PCK in different subject areas.
2. The results of this study may serve as a guide to the school heads in crafting their school learning action cells on how to address the Mathematics Teaching Anxiety of the teachers.
3. The School Principal may conduct a classroom observation quarterly to monitor the efficaciousness of the teachers and ensure adequate instructional delivery to the students.
4. Future researchers who would like to embark on mathematics teaching efficacy mediate the relationship between pedagogical content knowledge and mathematics teaching anxiety can use the same instrument used in this study to be administered on a larger scale.

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