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Teachers' Mathematical Content Knowledge and Pedagogical Skills in Relation to the Learners' Mathematical Achievement in Cagdianao District, Dinagat Islands

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Abstract

This quantitative correlational study investigated the relationship between mathematics teachers' content knowledge and pedagogical skills and the learners' mathematics achievement in secondary schools in Cagdianao District, Dinagat Islands. Participants included 20 secondary mathematics teachers and 326 students from Grades 7 to 11, selected through total enumeration and stratified random sampling, respectively. Data were gathered through validated survey questionnaires measuring teachers' mathematical content knowledge, pedagogical skills, and students' self-assessed competencies, alongside students' final grades in mathematics. Results revealed that teachers generally possessed high content knowledge and pedagogical skills, though technology-related pedagogical skills were only moderately satisfactory. Educational attainment significantly influenced content knowledge and selected pedagogical skills, but no significant correlation was found between teachers' content knowledge and students' achievement. Findings underscore the importance of continuous professional development, particularly for teachers without postgraduate qualifications. Recommendations include targeted training, incentives for advanced study, and ongoing assessment of teachers' mathematical proficiency to enhance student outcomes.

Keywords: Content Knowledge, Pedagogical Skills, Mathematics Achievement, Mathematics Competencies, Dinagat Islands, Philippines

Introduction

Effective mathematics instruction hinges on teachers' mastery of both content knowledge and pedagogical content knowledge (PCK), enabling them to convey mathematical concepts in ways that foster deep understanding and problem-solving abilities (Alshehri, 2022). Contemporary meta-analyses affirm that teacher content knowledge and PCK remain critical predictors of student achievement, influencing how well learners grasp mathematical ideas and engage in effective reasoning (May 2025). In the Philippine context, persistent low performance in mathematics among learners—exemplified by only 17 percent reaching the minimum standard at the end of primary education—underscores an urgent need to address instructional quality (Philippine Statistics Authority, 2025). Together, these findings justify investigating how mathematics teachers' content knowledge and pedagogical skills relate to students' mathematical performance in Cagdianao District, Dinagat Islands, where targeted professional development may markedly enhance learning outcomes.

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Aim

The study aimed to determine the relationship between mathematics teachers' content knowledge and pedagogical skills and the learners' mathematics achievement in secondary schools in the Cagdianao District, Dinagat Islands.

Research Questions

1. What is the profile of mathematics teachers in terms of:
    - age
    - sex
    - highest educational attainment
    - degree and major
    - subjects taught
    - school assigned?
2. What is the level of content knowledge possessed by mathematics teachers?
3. What is the level of pedagogical skills of mathematics teachers in terms of:
    - set induction
    - stimulus variation
    - nonverbal communication
    - questioning
    - reinforcement
    - technology-related skills?
4. What is the extent of learners' mathematics competencies in terms of:
    - mathematical concepts
    - procedural fluency
    - problem-solving skills
    - reasoning and communication skills
    - metacognitive awareness?
5. Is there a significant relationship between mathematics teachers' content knowledge and pedagogical skills and the learners' mathematics achievement?

Hypotheses

At the 0.05 level of significance:

1. There is no significant relationship between teachers' content knowledge and learners' mathematics achievement.
2. There is no significant relationship between teachers' pedagogical skills and learners' mathematics achievement.
3. There is no significant relationship between teachers' content knowledge and their pedagogical skills.

Literature Review

Recent educational research consistently underscores the critical roles of both content knowledge (CK) and pedagogical content knowledge (PCK) in driving students' mathematics achievement. Shulman (1986) first articulated PCK as a unique amalgam of subject-matter mastery and the ability to teach it effectively—a concept that has since become foundational in teacher education. A 2024 meta-analysis revealed that improvements in CK and PCK through professional development are strongly associated with observed enhancements in instructional practices (Aksu & Kul, 2024).

A 2025 systematic meta-analysis reported a positive relationship between PCK and CK, highlighting that teachers with stronger pedagogical content knowledge also tend to exhibit higher levels of content mastery (Yang et al., 2025). Complementing this, a recent meta-study synthesizing professional development programs in math and

science education concluded that initiatives targeting both CK and formative assessment are more effective in improving classroom instruction and student learning compared to those focusing solely on general instructional methods (Hill et al., 2025).

Moreover, the integration of technology into mathematics instruction—as modeled by the Technological Pedagogical Content Knowledge (TPACK) framework—has been shown to significantly aid student learning. A 2025 study of mathematics teachers in the Philippines found that while teachers demonstrated high competence in aligning technology with content (TCK), their foundational technological knowledge (TK) was comparatively weaker, pointing to areas for targeted development (Sumandal et al., 2025). The TPACK framework itself remains a robust tool for conceptualizing how teaching efficacy is enhanced through the blending of technological, pedagogical, and content knowledge (Mishra & Koehler, 2006).

These findings emphasize that raising students' mathematical achievement—especially in contexts like Cagdianao District—necessitates a focused enhancement of mathematics teachers' content knowledge, pedagogical capabilities, and their ability to integrate technology effectively.

Theoretical and Conceptual Framework

This study is grounded in Shulman's (1986) Pedagogical Content Knowledge (PCK) Theory, which emphasizes that effective teaching requires the integration of deep subject-matter knowledge with strategies for making content comprehensible to learners. PCK bridges the gap between knowing mathematics and knowing how to teach it, highlighting the role of instructional decisions, adaptation to learner needs, and the use of representations and analogies (Depaepe et al., 2013). This perspective is supported by recent findings that teachers who possess high PCK tend to foster greater conceptual understanding and problem-solving abilities in students (Aksu & Kul, 2024).

Complementing this, the Technological Pedagogical Content Knowledge (TPACK) Framework (Mishra & Koehler, 2006) serves as the second theoretical anchor. TPACK extends PCK by incorporating technological knowledge as an essential component for 21st-century teaching. It posits that effective mathematics instruction now requires the seamless integration of technology with pedagogy and content, enabling teachers to create dynamic, interactive, and personalized learning environments. Recent studies confirm that strategic technology integration in mathematics improves student engagement and achievement (Sumandal et al., 2025).

Conceptual Framework

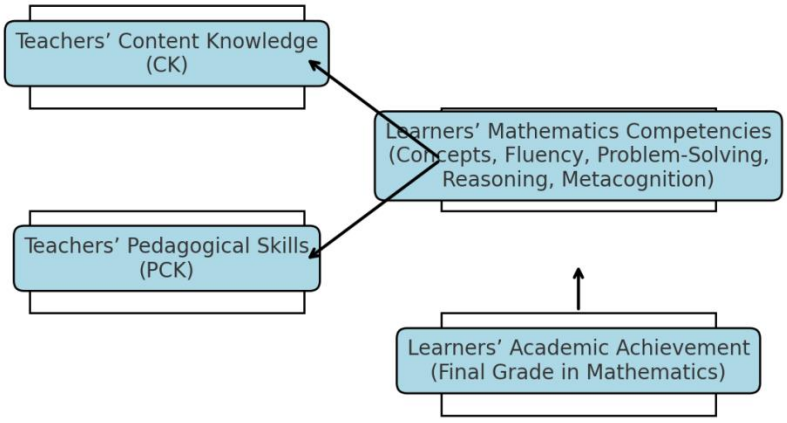

Figure 1. Conceptual Framework Showing the Relationship Between Teachers' Content Knowledge, Pedagogical Skills, Learners' Mathematics Competencies, and Academic Achievement

Methodology

The study employed a descriptive-correlational research design to examine the relationship between mathematics teachers' content knowledge, pedagogical skills, and learners' mathematics achievement in secondary schools in

the Cagdianao District, Dinagat Islands during the 2023–2024 school year. The respondents comprised 20 mathematics teachers selected through total enumeration and 326 students determined via stratified random sampling from five public secondary schools. Data were collected using two validated and reliability-tested questionnaires: one for teachers covering demographic profile, content knowledge, and pedagogical skills, and one for students assessing demographic profile, self-perceived mathematics competencies, and final grades in mathematics. Descriptive statistics (frequency, percentage, mean, standard deviation) were used to determine teacher and student profiles and competency levels, while independent samples t-tests and one-way ANOVA assessed differences in teacher competencies based on profile variables. Pearson's r correlation was applied to measure the relationships among teachers' content knowledge, pedagogical skills, learners' competencies, and academic achievement, with all analyses conducted at a 0.05 significance level.

Results and Discussion

Table 1. **Profile of Mathematics Teachers**

Profile Variable	**Category**	**Frequency**	**Percentage (%)**
Age	26–30	7	35.0
	31–35	8	40.0
	36–40	3	15.0
	46–50	1	5.0
	56–60	1	5.0
Sex	Male	10	50.0
	Female	10	50.0
Educational Attainment	Bachelor's Degree	10	50.0
	With Master's Units	9	45.0
	Master's Degree	1	5.0
Degree & Major	BSEd Mathematics	18	90.0
	BSCS/TCC Math	1	5.0
	BSEd Biology	1	5.0

Table 1 presents the demographic profile of the mathematics teacher-respondents in the Cagdianao District. Most teachers were in the 31–35 age group, with an equal gender distribution. Half held a bachelor's degree, and nearly half had earned units in a master's program. The majority specialized in mathematics, reflecting strong subject-matter alignment with their teaching load.

Table 2. **Level of Content Knowledge**

Indicator	**Mean**	**SD**	**Interpretation**
Understanding basic concepts	3.54	0.48	High
Using mathematical thinking	3.45	0.50	High
Applying to real-world problems	3.18	0.41	High
Overall Mean	**3.39**	**0.46**	**High**

Table 2 shows the level of content knowledge among teachers. The overall mean score was high, indicating strong mastery of mathematics concepts. Teachers scored highest in understanding basic concepts and applying mathematical thinking, with slightly lower ratings in applying mathematics to real-world problems.

Table 3. **Level of Pedagogical Skills**

Skill Area	Mean	Interpretation
Set induction	3.60	High
Reinforcement	3.55	High
Questioning techniques	3.52	High
Technology integration	3.18	Moderately High
Overall Mean	**3.46**	**High**

Table 3 reports the teachers' pedagogical skills. The results indicate a high overall rating, with strengths in set induction, reinforcement, and questioning techniques. However, technology integration was rated moderately high, suggesting an area for professional development.

Table 4. **Extent of Learners' Mathematics Competencies**

Competency	Mean	Interpretation
Procedural fluency	3.50	High
Problem-solving skills	3.48	High
Reasoning & communication	3.45	High
Metacognitive awareness	3.38	High

Table 4 outlines the learners' self-assessed mathematics competencies. Competencies in procedural fluency, problem-solving, and reasoning and communication were rated high, while metacognitive awareness was slightly lower but still high, indicating that students generally perceive themselves as competent in core mathematical skills.

Table 5. **Academic Achievement of Students (Final Grades in Mathematics)**

Descriptor	Frequency	Percentage (%)
Outstanding (90–100)	25	7.67
Very Satisfactory (85–89)	89	27.30
Satisfactory (80–84)	136	41.72
Fairly Satisfactory (75–79)	76	23.31

Table 5 presents the students' academic achievement in mathematics based on their final grades. The largest proportion fell in the satisfactory range, followed by very satisfactory, fairly satisfactory, and a smaller group in the outstanding category.

Table 6. **Significant Differences in Content Knowledge by Profile**

Profile Variable	Significant?	p-value	Remarks
Educational Attainment	Yes	< 0.05	Higher for postgraduate holders
Age	No	> 0.05	—
Sex	No	> 0.05	—
Major	No	> 0.05	—

Table 6 shows the significant differences in teachers' content knowledge by profile variables. Educational attainment had a significant effect, with higher scores among those with postgraduate qualifications, while age, sex, and major showed no significant differences.

Table 7. **Significant Differences in Pedagogical Skills by Profile**

Profile Variable	Significant?	p-value	Remarks
Educational Attainment	Yes	< 0.05	Significant in stimulus variation & questioning
Age	No	> 0.05	—
Sex	No	> 0.05	—
Major	No	> 0.05	—

Table 7 illustrates the significant differences in pedagogical skills by profile variables. Again, educational attainment was significant, particularly in stimulus variation and questioning skills, while other variables showed no significant impact.

Table 8. **Relationship Between Content Knowledge, Pedagogical Skills, and Students' Performance**

Variables Correlated	r-value	p-value	Interpretation
CK & Students' Achievement	—	> 0.05	No significant correlation
PCK & Students' Competencies	—	< 0.05	Positive but weak correlation
CK & PCK	—	< 0.05	Significant positive correlation

Table 8 summarizes the relationships among content knowledge, pedagogical skills, and students' performance. No significant correlation was found between content knowledge and students' achievement, but there was a positive correlation between certain pedagogical skills and student competencies. A significant positive relationship was also found between content knowledge and pedagogical skills, indicating these competencies tend to improve together.

Implications of the Results

The results suggest several important implications for mathematics education in the Cagdianao District. First, the strong content knowledge and pedagogical skills of teachers (Tables 2 and 3) indicate a solid foundation for delivering quality instruction. However, the moderate rating in technology-related skills highlights the need for targeted professional development in technology integration to align with 21st-century teaching standards.

The finding that educational attainment significantly influences both content knowledge and specific pedagogical skills (Tables 6 and 7) underscores the value of encouraging and supporting teachers to pursue postgraduate studies. Providing incentives such as scholarships, study leaves, or salary adjustments could help elevate qualifications and, in turn, teaching effectiveness.

Although no significant correlation was found between content knowledge and students' mathematics achievement (Table 8), the positive association between certain pedagogical skills and student competencies emphasizes that how content is delivered may be as critical as the content itself. This suggests that training programs should focus not only on subject mastery but also on enhancing interactive and student-centered teaching strategies, such as questioning techniques and reinforcement methods.

The generally satisfactory to very satisfactory student performance (Table 5) combined with high self-assessed competencies (Table 4) suggests a positive learning environment. However, the slightly lower metacognitive awareness signals a need for instructional approaches that explicitly foster students' ability to plan, monitor, and evaluate their own learning processes.

Overall, the results point to the necessity of balanced teacher development programs that integrate advanced content mastery, refined pedagogical techniques, and effective technology use to sustain and improve student achievement in mathematics.

Conclusion

The study established that mathematics teachers in the Cagdianao District possess high levels of content knowledge and pedagogical skills, with notable strengths in set induction, reinforcement, and questioning

techniques. However, technology-related pedagogical skills were rated only moderately high, signaling an area for targeted improvement. Educational attainment emerged as a significant factor influencing both content knowledge and selected pedagogical skills, favoring those with postgraduate qualifications. While no significant relationship was found between content knowledge and students' academic performance, certain pedagogical skills were positively associated with learners' mathematics competencies. Students generally demonstrated high levels of self-assessed mathematical abilities and satisfactory to very satisfactory academic performance, although metacognitive awareness was slightly lower. These findings suggest that the way mathematics is taught—particularly through effective pedagogical strategies—may have a greater direct influence on student competencies than content knowledge alone.

Recommendations

It is recommended that teacher professional development initiatives in the Cagdianao District prioritize the enhancement of technology integration skills to strengthen the delivery of mathematics instruction in line with 21st-century learning demands. The Department of Education and local school administrators should consider providing incentives, scholarships, or structured career development pathways to encourage teachers to pursue postgraduate studies, thereby raising both content mastery and pedagogical expertise. Training programs should focus on refining interactive teaching strategies, especially questioning techniques and reinforcement, as these have shown a positive impact on learners' competencies. Furthermore, instructional approaches should explicitly promote metacognitive skills to help students develop greater autonomy in learning. Regular assessments of teachers' competencies and targeted interventions can ensure that both content knowledge and pedagogical skills continue to evolve, ultimately contributing to sustained improvements in students' mathematics achievement.

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