Binomial Logistic Regression of Teaching Trajectories of Mathematics Teacher in National High Schools

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ABSTRACT

This research explored the teaching career paths of Mathematics teachers in Secondary schools in South Cotabato National High Schools, with their application of procedural and conceptual knowledge and how they are connected to chosen teacher profile variables. Utilizing a correlational design research, the study gathered information from 227 Mathematics teachers in six municipalities. Four main instruments were employed: (1) a teacher profile from gathering personal, professional, and teaching-aid data; (2) lesson plan rubrics measuring whether teachers' planning reflected procedural or conceptual approaches; (3) test questionnaire rubrics scaling items into lower- or higher-order thinking skills; and (4) a perception survey measuring teachers' beliefs regarding the value of procedural versus conceptual instruction. Findings showed that while most teachers reported having high to moderate respect for conceptual knowledge-including greater understanding, practical application in the world, and higher-order thinking-most lesson plans and test questionnaires predominantly consisted of procedural tasks.

Binomial logistic regression was subsequently conducted to investigate which demographic or professional variables predicted most accurately whether teachers preferred conceptual or procedural approaches. Contrary to expectations, the sole statistically significant predictor was computer-based Mathematics application use: teachers who incorporated these tools were more likely to plan and implement lessons consistent with conceptual teaching approaches. The other profile variables, including years of service, age, and level of education, did not have a statistically significant effect. These results support the necessity of technology integration to promote more conceptually grounded Mathematics teaching. They also demonstrate a discrepancy between what teachers believe and their actual classroom practices. The research advises targeted professional training to help teachers' ability to transform intentions into realities within the classroom and, as an end goal, enhance students' engagement and learning in Mathematics.

Keywords: Conceptual Knowledge, Procedural Knowledge, Teaching Trajectory

INTRODUCTION

In today’s educational landscape, students often seek quick and easy methods to grasp mathematical concepts, which can hinder their deeper understanding. This is particularly evident when it comes to foundational topics such as integers and the relationship between positive and negative numbers—concepts many students struggle with despite prior exposure. The core issue often lies in the lack of a comprehensive understanding of these fundamental mathematical principles, which include both conceptual and procedural knowledge. By examining the interplay between these two knowledge categories, educators can address gaps in students' mathematical understanding more effectively.

The role of mathematics teachers is indispensable in shaping learners’ appreciation, engagement, and achievement in the discipline. International and local studies (e.g., Schneider & Stern, 2010; Star, 2007) consistently show that students who develop a deep and holistic understanding of mathematics attribute this growth to teachers who model and nurture equally holistic instructional approaches. Conversely, when instruction is fragmented or overly procedural, learners’ attitudes toward mathematics often decline, and their performance stagnates.

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In the Philippines, this pattern is readily observable. National achievement test reports and classroom-level assessments indicate that many Filipino students still struggle to master foundational topics—particularly integers, fractions, and algebraic reasoning—despite repeated exposure across grade levels. Students frequently prefer shortcut strategies that promise quick answers over the sustained effort required for comprehensive problem solving, signalling gaps in their conceptual foundations. The recurring challenge to "understand the mathematics behind the rules" underscores the urgency of examining how teachers frame, connect, and sequence mathematical ideas in everyday lessons.

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For mathematics teachers, a strong grasp of both conceptual and procedural knowledge is essential for instilling confidence in their students and enhancing their teaching efficacy. Teachers who effectively combine these two knowledge types can better address student misconceptions and improve learning outcomes. This study aims to explore the strategies employed by secondary mathematics teachers in DepEd South Cotabato to enhance student learning. Specifically, it focuses on the pedagogical methods used in lesson plans and test questionnaires, as well as how teachers' perceptions of teaching mathematics influence their instructional choices. Additionally, the study investigates how teachers' personal and professional profiles impact their teaching strategies.

As Schneider and Stern (2010) assert, understanding the cognitive relationships between different kinds of knowledge is crucial for designing effective learning environments. Some learning theories suggest that conceptual knowledge forms the basis for procedural knowledge, while others propose a bidirectional relationship between the two. However, as Star (2007) notes, many mathematics educators overlook the importance of conceptual understanding, often due to the lack of a clear framework for discussing this kind of knowledge. Conceptual knowledge—knowing the "why" behind mathematical rules—complements procedural knowledge, which focuses on the "how" of problem-solving (Affiche, 1985).

This research intends to identify the predominant teaching strategies used by secondary mathematics teachers in South Cotabato, with a focus on their integration of conceptual and procedural knowledge. The study will analyze lesson plans, test questionnaires, and teacher profiles to determine how these factors influence teaching trajectories and strategies. Teachers are expected to demonstrate fluency in both types of knowledge, and this integration can significantly enhance their ability to address students' learning challenges.

Statement of the Problem

The primary objective of this study is to investigate the teaching trajectories of secondary mathematics teachers in South Cotabato, focusing on the balance between procedural and conceptual knowledge. The study aims to analyze lesson plans, test questionnaires, and the association of these teaching practices with the teachers' profiles.

Specifically, the study seeks to answer the following questions:

1. What are the profiles of secondary mathematics teachers in South Cotabato?
2. What are the teachers' perceptions of procedural and conceptual knowledge in terms of:
   2.1. Lesson Plans?
   2.2. Test Questionnaires?
   2.3. Teaching Mathematics?
3. Which type of knowledge—procedural or conceptual—is more dominant in the teaching trajectories of secondary mathematics teachers in South Cotabato?

4. Which between Procedural and Conceptual Knowledge appears to be more dominant in Mathematics teaching trajectories of the secondary Mathematics teachers of South Cotabato?
5. Is there a significant association between perceived dominant (procedural/conceptual) knowledge and the following factors in teachers' profile profiles?

METHODOLOGY

Research Design

This study employed a correlational research design to examine the relationship between secondary Mathematics teachers' profiles and their teaching methodologies, specifically focusing on their use of procedural and conceptual knowledge. The primary goal was to determine the extent to which these teacher profiles influence their choice of teaching strategies. This approach allows for an in-depth analysis of how variables such as teacher demographics and professional background correlate with pedagogical practices, particularly in terms of lesson planning and test question formulation. The findings aim to contribute valuable insights into optimizing teaching practices in Mathematics.

Locale of the Study

The study was conducted in the province of South Cotabato, located in the southern part of the Philippines, within the SOCCSKSARGEN region. Specifically, the research was carried out across six municipalities: Lake Sebu, Norala, Polomolok, T'boli, Tantangan, and Tupi. South Cotabato is known for its cultural diversity and geographic variability, offering a representative sample of the province's educational environment. The province hosts 97 National High Schools across its municipalities, providing a broad base for the study's participant selection.

Respondents of the Study

The study targeted secondary Mathematics teachers from National High Schools in the selected municipalities of South Cotabato. Teachers who were either Mathematics majors or non-Mathematics majors were included. The sample represented educators across all secondary grade levels, ensuring a comprehensive understanding of the teaching practices across different teaching backgrounds. The study was conducted during the 2019-2020 academic year, capturing a snapshot of teaching practices in this region.

Sampling Technique

A complete enumeration sampling method was used, meaning that all secondary Mathematics teachers in the selected schools were included in the study. This approach was chosen to ensure that the data accurately reflected the teaching practices of all relevant teachers within the six municipalities. In total, 227 teachers participated in the study, providing a broad and inclusive sample that represents the diversity of teaching approaches in the area.

Data Gathering Instruments

The research employed several instruments to collect data on teacher profiles, their pedagogical approaches, and their perceptions of teaching Mathematics:

- Teacher Profile Form: This form collected demographic information, including educational background, professional experience, and teaching affiliations.
- Survey on Teachers' Perception of Teaching Mathematics: Adapted from Longanilla (2019), this survey utilized a 5-point Likert scale to measure teachers' emphasis on procedural and conceptual knowledge in their teaching methods.
- Lesson Plan and Test Questionnaire Rubric: A self-constructed rubric was used to assess the cognitive level of lesson plans and test questions created by the teachers. These rubrics focused on determining the extent to which the plans and questions aligned with procedural or conceptual knowledge, based on Bloom's Taxonomy.

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These instruments were validated through expert review and piloting, ensuring that they accurately measured the study's objectives.

Data Gathering Procedure

The data collection process involved several steps to ensure thorough and ethical research conduct:

- Permission and Consent: Prior to data collection, formal permission was secured from the Schools Division Superintendent of South Cotabato, as well as from school heads. A consent letter was provided to all participants, ensuring voluntary participation and confidentiality.
- Data Collection: The data was gathered over five consecutive days in each of the selected municipalities, with each teacher providing information on their profile and completing the survey. Teachers also submitted lesson plans and test questionnaires for evaluation. The data collection took place during the third and fourth quarters of the academic year, ensuring a consistent timeline for gathering information.

Statistical Treatment of Data

The study utilized a range of statistical tools to analyze the collected data:

- Descriptive Statistics: Measures such as means and percentages were used to summarize teacher profiles and their responses to the survey items on teaching preferences.
- Binomial Logistic Regression (BLR): This method was employed to predict the relationship between teachers' profiles (independent variables) and their pedagogical approaches (dependent variables). The BLR analysis provided insights into how various teacher characteristics influence the use of procedural and conceptual knowledge in teaching.
- Pearson Chi-Square and Wald Chi-Square: These tests were used to determine the associations between categorical and continuous variables, respectively, and to assess the significance of relationships between teacher profiles and teaching strategies.
- Reliability and Validity: To ensure the reliability and validity of the instruments, expert validation was conducted. Content validity was assessed to ensure the tools measured what they intended to, while face validity confirmed the appropriateness of the instruments based on expert judgment.

The methodology outlined in this chapter provides a robust framework for investigating the correlation between teacher profiles and their pedagogical practices in Mathematics. Through a combination of surveys, teacher profiling, and lesson plan assessments, the study aimed to generate empirical data that can inform future strategies for enhancing teaching effectiveness. By applying advanced statistical techniques, the study ensures that its findings are both reliable and valid, contributing to the body of knowledge on teacher practices in secondary education.

RESULTS AND DISCUSSION

This chapter reports and interprets the study's findings, analyzing the data in direct relation to the research objectives.

Profiles of Teachers and Teaching Approaches

Teachers play a critical role in facilitating students' understanding and problem-solving skills in mathematics. To cultivate a deep understanding of mathematical concepts, it is essential for teachers to possess a diverse and effective repertoire of teaching strategies that engage students and foster progressive learning experiences. This study aimed to explore how secondary mathematics teachers in South Cotabato integrate both conceptual and procedural knowledge into their instruction, focusing on their teaching practices and profiles.

The study profiled 227 secondary mathematics teachers from various regions, including Lake Sebu (26), Norala (37), Polomolok (73), T'boli (33), Tantangan (11), and Tupi (47). The demographic analysis revealed that the majority of the respondents were female (121) and aged 30-39 (86), with the predominant ethnic group being Hiligaynon (136). A significant number of teachers (209) taught in large schools, and 161 taught

primarily in Junior High. Most respondents (196) held Bachelor's Degrees, meeting the minimum requirement for employment in the Department of Education, while 98 were ranked as Teacher I. Over half of the teachers were married.

In terms of teaching practices, 92% of teachers used PowerPoint presentations, and 75% incorporated computer applications like Excel, Geogebra, and SketchUp in their lessons. These findings indicate a shift towards more modern, technology-infused teaching methods aimed at enhancing student engagement and conceptual understanding.

Teachers' Perceptions of Procedural and Conceptual Knowledge

The study presents a nuanced view of how mathematics teachers both value and operationalize procedural and conceptual knowledge in their classrooms. Lesson-plan analysis showed that 61 percent of plans emphasized procedural steps, and 78 percent of test items targeted procedural skills. Paradoxically, survey data reveal that teachers rate conceptual understanding slightly higher (M = 3.85) than procedural fluency (M = 3.74; SD = 0.248), voicing strong agreement that mathematics instruction should nurture deeper reasoning, real-world application, and higher-order thinking (Hiebert & Lefevre, 1986; Dreher et al., 2018). Individual items on the conceptual scale ranged from 3.36 to 4.24, and teachers particularly endorsed the statement that students "should learn to apply mathematics in business and industry," confirming the practical importance they attach to conceptual learning.

This mismatch between belief and practice echoes Rittle-Johnson and Alibali's (1999) claim that conceptual and procedural knowledge are bidirectionally linked: each reinforces the other, yet classroom pressures often skew instruction toward easier-to-plan procedures. Consistent with Nathan and Knuth's (2003) finding that rich mathematical discourse can prompt teachers to rethink their own balance of concepts and skills, several observed lessons in the present study successfully wove the two strands together. Windschitl (2004) similarly underscores that teachers' grasp of both knowledge types is critical for designing engaging tasks. These converging insights suggest that, with targeted professional development, stronger curricular supports, and deliberate reflection time, teachers can align their professed commitment to conceptual understanding with the procedural realities of daily practice—an alignment that later sections of this study will examine in relation to teacher background, training opportunities, and resource constraints.

Table 1Summary of Wald Chi-Square for Age & Length of Service and Teaching Trajectories

	W	Df	p-value
Age	1.3	1	.260
Length of Service	0.9		.336

Neither age (W = 1.27, df = 1, p = .260) nor length of service (W = 0.92, df = 1, p = .336) showed a statistically significant link to the kind of knowledge teachers stress in class. Put simply, both early-career and veteran educators tend to lean on procedural instruction, suggesting that preference is likely driven by systemic factors—curricular demands, assessment pressures, or available materials—rather than by career stage alone.

Table 2 Summary of Pearson Chi-Square for other Demographics and Teaching Trajectories

	W	Df	p-value
Gender	1.794	1	.180
Ethnicity	0.927	3	.819
Marital Status	0.082	1	.774
School Size	0.654	1	.419
Teaching Appointment	1.251	2	.535
Teaching Position	1.334	2	.856
Level of Education	1.526	1	.217
Use of PPT	0.654	1	.419
Use of Computer Application	10.990	1	.001

Applying the same statistical lens to gender, ethnicity, marital status, school size, appointment type, position, highest degree earned, and even routine slide-deck use reveals no meaningful link with teachers' instructional emphasis: every test in these categories produced p-values greater than .18, well above conventional significance thresholds. The lone exception is teachers' engagement with computer-based mathematics applications—GeoGebra, Desmos, spreadsheets, and similar tools—where the association is both large and clear ($\chi^2 = 10.99$, df = 1, p = .001). In this subgroup, frequent technology users are markedly more inclined toward procedural approaches.

At first glance this might seem counterintuitive, because technology integration is widely recommended as a pathway to richer, more conceptually grounded mathematics instruction (Hair, Black, Babin, & Anderson, 1998). Yet the data show that, in practice, routine use of such software currently predicts a procedural orientation, echoing similar findings on technology's influence on teaching strategies (Khongji & Nonglosap, 2013). These results suggest that while digital tools have the potential to deepen conceptual understanding, realizing that potential depends on how the tools are deployed in everyday classroom practice.

Table 3 Strength of Association by Nagelkerke

	R^2
Constant	0.31

The Nagelkerke R^2 of .31 signals a moderate effect: technology use does not fully determine instructional style, yet it explains roughly one-third of the variance—enough to warrant attention in professional-development planning.

Table 5 Variables in the Equation

	B	S.E.	Wald	Df	Sig.	Exp(B)
Constant	-1.324	.418	10.045	1	.002	0.266
Math Applications	1.682	385	19.007	1	<.001	5.315

The logistic model reinforced these findings. After controlling for other demographics, teachers who integrate mathematics applications were 5.32 times more likely to emphasize procedural knowledge (B = 1.68, SE = 0.39, Wald $\chi^2 = 19.01$, $p < .001$, Exp(B) = 5.32). The constant term (B = –1.32, p = .002) indicates that, in the absence of such tools, the baseline probability of a procedural focus drops substantially.

Teachers' instructional trajectories in mathematics are shaped by a constellation of personal, educational, and professional characteristics. Personal attributes (e.g., age, gender, and emotional stability), formal preparation (degrees earned, mathematics-specific coursework), and career experience (length of service, appointment status, and prior roles) collectively inform how teachers design lessons and assessments. Within this mix, emotional stability and specialized knowledge of mathematics education stand out as decisive factors in tilting practice toward procedural rather than conceptual emphases. The study also shows that these trajectories yield the greatest benefits when they are enacted in supportive school environments and under favorable classroom conditions, underscoring the dynamic interaction between teacher profiles and instructional strategy.

Teachers' instructional choices rarely pivot on a single variable; instead, they reflect a dense matrix of personal beliefs, professional norms, and situational pressures. Consistent with Clarke et al.'s (2012) finding that lesson planning is shaped by educational beliefs, resources, and external mandates, the present data show that factors often assumed to matter—financial security, highest academic degree, or attendance at seminars and workshops—exert no statistically significant influence on whether teachers emphasize conceptual or procedural knowledge. In every one of these categories the p-values exceed .18, underscoring the absence of a meaningful association.

The one robust predictor that does surface is routine engagement with computer-based mathematics applications such as GeoGebra, Desmos, or spreadsheet software ($\chi^2 = 10.99$, df = 1, p = .001). Teachers who rely heavily on these tools tend to construct more procedurally oriented lesson plans and test items, a pattern that dovetails with earlier reports of technology's influence on instructional strategy (Khongji & Nonglosap,

2013) even as it complicates calls for technology to foster deeper conceptual learning (Hair, Black, Babin, & Anderson, 1998).

This tension resonates with a broader body of scholarship. Lamberg (2012) argues that whole-class discussions can help students knit conceptual insights to procedural fluency, while Prozesky (2000) cautions that fluency alone is insufficient for mathematical mastery. Tall's (1991) work on visualization shows how imagery bridges abstract ideas and symbolic procedures, and Zuya (2012) demonstrates that a solid conceptual footing in algebra supports flexible procedural problem-solving. Together, these perspectives suggest that technology is not intrinsically conceptual or procedural; its pedagogical impact depends on how teachers orchestrate discourse, visualization, and practice opportunities within the constraints—and affordances—of their classrooms.

CONCLUSIONS

The study led to the following conclusions:

1. Teacher Profile: The majority of teachers were aged 30-39, with females comprising 121 of the respondents. Most teachers were Hiligaynon, married, and taught in large schools. A significant portion (71%) taught in Junior High, with 43% holding the rank of Teacher I. Most (86%) held Bachelor's degrees, and 92% used PowerPoint presentations, with 75% incorporating computer-based applications in their teaching.
2. Teaching Trajectories:
   2.1 Lesson Plans: Teachers predominantly designed lesson plans that emphasized procedural knowledge, with a focus on memorization and task execution.
   2.2 Test Questionnaires: The test questions largely reflected procedural knowledge, emphasizing lower-order thinking skills and factual recall rather than conceptual understanding.
3. Teacher Perception: Teachers generally scored higher (3.85) on the conceptual knowledge scale compared to procedural knowledge (3.74), indicating a preference for conceptual understanding. However, this perception did not align with their actual teaching practices.
4. Demographic Associations: There were no significant correlations between the teachers' demographics and their teaching approaches. All categories, except the use of computer applications, favored procedural knowledge.
5. Use of Computer Applications: The use of computer-based mathematics applications was significantly associated with a preference for procedural knowledge, with a moderate effect size (Nagelkerke R2 = 0.31) and a logistic regression odds ratio of 5.375.

RECOMMENDATIONS

Based on the findings, the following recommendations are made:

1. Awareness and Training: Teachers should be made more aware of teaching trajectories that emphasize conceptual knowledge to balance procedural teaching.
2. Peer Conferences: Regular peer conferences or Learning Action Cell (LAC) sessions should be encouraged to foster discussions on integrating conceptual understanding into teaching practices.
3. Curriculum and Pedagogy: The Department of Education should conduct more training focused on classroom pedagogy that enhances conceptual teaching in mathematics.
4. Integration of Technology: Teachers who use computer mathematics applications should be encouraged to adopt more conceptually focused teaching strategies to improve students' understanding of mathematical concepts.
5. Further Research: Future studies should explore the development of conceptual teaching strategies in other regions to enhance the conceptual knowledge of mathematics teachers.

Ethical Approval

This study was conducted in accordance with ethical guidelines and principles to ensure the protection of participants' rights. Prior to the commencement of data collection, approval was obtained from the Schools

Division Superintendent of South Cotabato, as well as from the relevant school authorities. All participants were provided with an informed consent form detailing the purpose of the study, the voluntary nature of participation, and assurances of confidentiality. Participants were free to withdraw from the study at any stage without any repercussions. The research adhered to ethical standards in the handling and storage of data to protect the privacy and anonymity of participants.

Conflict of Interest

The authors declare that there are no conflicts of interest in relation to the research presented in this paper. The study was conducted impartially, and no financial, personal, or professional relationships influenced the findings or interpretation of the data. The authors have no affiliations with any entities that could be perceived as conflicting with the academic integrity of the research.

Data Availability

The datasets generated and analyzed during this study are available upon reasonable request from the corresponding author. The data include teacher profiles, lesson plans, test questionnaires, and survey responses that were used to assess teaching trajectories in mathematics education. To maintain participant confidentiality, access to the raw data will be restricted and shared only with researchers or entities that meet ethical and confidentiality requirements.

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