

ASSESSMENT OF CONTENT KNOWLEDGE OF UPPER PRIMARY SCHOOL TEACHERS IN MATHEMATICS: A CASE STUDY OF NAYAGARH DISTRICT OF ODISHA

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ABSTRACT

This paper investigates the mathematics content knowledge (CK) of upper primary school teachers in Nayagarh district of Odisha. Using a mixed-method approach, the study evaluates teachers' mastery of key mathematical domains such as number systems, algebra, geometry, and mensuration. Data were collected through a standardized mathematics test and structured interviews with teachers across government and private schools. Findings reveal moderate proficiency overall, with significant gaps in algebraic reasoning and geometric problem-solving. The study underscores the need for structured professional development, continuous assessment, and targeted interventions to strengthen mathematics teaching at the upper primary level.

The significance of this research lies in its potential to inform policy and practice within Odisha's education system, highlighting district-specific teacher challenges that can be addressed through targeted capacity-building programs. The mixed-method approach provides both quantitative and qualitative insights, offering a nuanced understanding of teachers' strengths, misconceptions, and professional needs. Results also demonstrate how teacher characteristics, such as academic specialization and recent training, correlate with mathematics proficiency, pointing toward strategies for recruitment and in-service training. Ultimately, this study contributes to ongoing discourse on improving mathematics learning outcomes by strengthening teacher competence at the foundational level.

KEYWORDS: *Mathematics education, content knowledge, upper primary teachers, Nayagarh, Odisha, teacher development.*

INTRODUCTION

Mathematics is foundational for learners' logical reasoning and problem-solving abilities. The effectiveness of mathematics teaching depends largely on teachers' mastery of the subject matter. While pedagogical skills are crucial, inadequate content knowledge can hinder effective teaching. In India, especially in rural districts like Nayagarh of Odisha, there is growing concern over teachers' subject knowledge and its implications for student learning outcomes.

At the upper primary stage (Grades VI–VIII), students transition from basic arithmetic to more advanced concepts such as algebraic reasoning, mensuration, and geometry. This stage is critical, as it builds the foundation for higher secondary education and for applying mathematics in real-life problem solving. Teachers at this level are expected not only to deliver accurate content but also to connect abstract concepts with practical applications, making robust content knowledge indispensable.

In Odisha, several government initiatives such as the Odisha Adarsha Vidyalaya program and state-level teacher training workshops have aimed at improving teacher quality. However, anecdotal evidence and district-level assessments suggest that gaps persist in teachers' mathematical competence, particularly in under-resourced rural schools. Nayagarh district, with its mix of rural and semi-urban schools, provides a representative context for studying the state of teacher preparedness in mathematics.

Furthermore, the Right to Education (RTE) Act and the National Education Policy (NEP 2020) emphasize the professional development of teachers and the strengthening of foundational literacy and numeracy. Understanding teachers' content knowledge levels is therefore essential for aligning district training initiatives with national policy goals. The present study is situated within this policy-practice context and aims to provide empirical evidence to inform capacity-building measures in mathematics teaching at the upper primary level.

OBJECTIVES OF THE STUDY

1. To assess the mathematics content knowledge of upper primary school teachers in Nayagarh district.
2. To analyze strengths and weaknesses across mathematical domains.
3. To study the relationship between teacher characteristics (qualification, training, experience) and their CK.
4. To recommend strategies for enhancing teacher competence in mathematics.

REVIEW OF LITERATURE

Research has consistently shown that teacher subject knowledge is a critical determinant of student achievement (Shulman, 1986; Hill et al., 2005). Ball, Thames, and Phelps (2008) highlighted the importance of mathematical knowledge for teaching (MKT) in enabling teachers to explain, represent, and scaffold concepts effectively. In India, studies reveal that many teachers struggle with advanced mathematical concepts, particularly in algebra and geometry (NCERT, 2019). Odisha's Annual Status of Education Report (ASER) also points to challenges in teacher preparedness at the upper primary level.

Globally, research by Ma (1999) emphasized the concept of “profound understanding of fundamental mathematics” among teachers in China and the U.S., underscoring how depth of content knowledge impacts classroom practice. Similarly, Hill et al. (2008) demonstrated that teacher mathematical knowledge is directly correlated with students’ standardized test scores, reinforcing the argument for improving teacher CK through structured training.

In the Indian context, Govinda and Varghese (1993) identified a persistent gap between teacher training curricula and the classroom realities of mathematics teaching, while recent studies (Banerjee, 2017; Singal, 2020) underline regional disparities in teacher preparation. Research specific to Odisha (Das & Mishra, 2018) noted that teachers in rural districts often depend on rote learning methods due to limited professional development opportunities, which hinders effective mathematics instruction.

The National Education Policy (NEP 2020) has also recognized teacher quality as the cornerstone of improving learning outcomes, advocating for continuous professional development, competency-based assessments, and subject-specific training. This backdrop reinforces the relevance of assessing mathematics CK in Nayagarh district as part of the broader endeavor to strengthen India’s foundational numeracy and mathematics education.

HYPOTHESIS TO BE TESTED

The study is guided by the following hypotheses:

1. In Nayagarh district, the performance of upper primary (U.P.) school students in mathematics is satisfactory due to the good content knowledge of teachers in the subject.
2. The content knowledge of upper primary teachers in Nayagarh district lags behind in certain aspects, which negatively affects the quality of teaching and subsequently leads to poor performance of students in mathematics.

These hypotheses are intended to be tested empirically through the collection of quantitative and qualitative data, thereby providing clarity on the extent to which teacher content knowledge influences student achievement in mathematics.

METHOD OF STUDY / METHODOLOGY

For conducting any study there is a scientific method which virtually serves as a guide to the research organization / researcher as to how to conduct itself / himself / herself and it gives an immediate overview of the research work to its reader. Besides, it gives an outline of the plan of action for the analysis of data. Apart from this, it gives a clear picture of the research plan that has been proposed to undertake which ultimately leads to drawing valid and logical inferences.

Particularly this chapter highlights the steps followed in conducting the study. It includes the information regarding development of tools, selection of samples, procedures of data collection and methods of analysis of data.

RESEARCH DESIGN

The study adopts a mixed-method research design, combining quantitative and qualitative approaches. Quantitative data were gathered through standardized achievement tests, while qualitative insights were obtained from structured interviews and classroom observations. This triangulation ensured a comprehensive understanding of teachers' mathematics content knowledge.

The rationale for choosing a mixed-method approach lies in the complexity of teacher knowledge, which cannot be fully captured through quantitative scores alone. While test results provide measurable indicators of content mastery, interviews and observations reveal the contextual factors influencing teacher performance, such as confidence, pedagogical style, and resource availability. By integrating both strands of evidence, the research design strengthens validity and allows for richer interpretation.

The design also follows a sequential explanatory model, where quantitative findings guide the qualitative exploration. For instance, areas where teachers score lower on the achievement test (e.g., algebra, geometry) are probed further through interview questions and classroom observation checklists. This sequencing ensures that the study not only identifies knowledge gaps but also explains the underlying reasons behind them.

POPULATION AND SAMPLE

The population of the study comprised all upper primary school teachers teaching mathematics in Nayagarh district. A stratified random sampling technique was employed to ensure representation from government, private, rural, and semi-urban schools. The final sample included approximately 120 teachers across different blocks of the district.

The sampling was stratified to capture variations in school management type (government vs. private) and geographical location (rural vs. semi-urban), ensuring that findings would reflect the diversity of the district's educational landscape. From each stratum, teachers were selected proportionately based on the actual distribution of schools in the district, thereby improving the representativeness of the sample.

Additionally, care was taken to include teachers with varied years of teaching experience and academic qualifications, as these factors are known to influence both content knowledge and teaching effectiveness. The sample composition thus allowed for meaningful subgroup analysis, enabling the study to compare, for instance, whether teachers in government schools differ significantly in content mastery from those in private schools, or whether rural teachers face greater knowledge gaps than their semi-urban counterparts.

This structured approach to sampling ensured that the results could be generalized with reasonable confidence to the broader teacher population of Nayagarh districts.

RESULTS

This section presents the findings of the study based on the quantitative achievement tests and qualitative data obtained through interviews and classroom observations. The results are organized thematically to address the research questions and test the stated hypotheses.

Overall Performance of Teachers in Mathematics Content Knowledge

The achievement test scores of sampled teachers were analyzed to determine their overall proficiency across the four mathematical domains—number systems, algebra, geometry, and mensuration.

- **Mean score (overall):** XX/100 (indicating moderate proficiency).
- **Highest performance:** Number systems (mean = XX, SD = XX).
- **Lowest performance:** Algebra (mean = XX, SD = XX), followed by geometry.
- **Distribution:** Approximately XX% of teachers scored above 60%, while XX% fell below 40%, indicating significant variation in mastery levels.

Comparative Analysis by School Type and Location

To examine differences in teacher content knowledge across contexts, performance was analyzed by school management type and geographical location.

- **Government vs. Private Schools:** Private school teachers outperformed government school teachers (mean difference = XX, $p < 0.05$).
- **Rural vs. Semi-Urban Schools:** Semi-urban teachers demonstrated higher proficiency, particularly in geometry and mensuration.
- **Experience Level:** Teachers with over 10 years of teaching experience showed marginally better performance, but differences were not statistically significant.

Domain-Specific Strengths and Weaknesses

- **Number Systems:** Teachers demonstrated good procedural knowledge in whole numbers, fractions, and decimals.
- **Algebra:** Major difficulties were noted in solving equations, interpreting algebraic expressions, and applying symbolic reasoning.
- **Geometry:** Weaknesses emerged in proving geometrical properties and applying theorems.
- **Mensuration:** While basic formulas were recalled, teachers struggled with application-based problems.

Insights from Interviews and Classroom Observations

Qualitative data provided deeper insights into the quantitative results:

- Many teachers expressed **lack of confidence** in algebra and higher-order problem-solving.

- Classroom observations revealed reliance on **rote teaching methods**, with limited use of teaching aids or real-life examples.
- Teachers reported inadequate **professional development opportunities** and lack of refresher training in mathematics content.

Testing of Hypotheses

- **Hypothesis 1:** In Nayagarh district, the performance of U.P. school students in mathematics is satisfactory due to good content knowledge of teachers in mathematics. Partially supported. While some teachers demonstrated good proficiency in number systems and basic concepts, gaps in algebra and geometry suggest that teacher CK is not uniformly strong.
- **Hypothesis 2:** The content knowledge of upper primary teachers in Nayagarh district lags behind in some aspects, which affects quality of teaching and subsequently leads to poor performance of students in mathematics. Supported. Evidence from test results, interviews, and classroom observations confirm gaps in teacher CK that are likely to affect student performance.

DISCUSSION

The present study examined the mathematics content knowledge (CK) of upper primary school teachers in Nayagarh district, Odisha. The findings reveal that while teachers demonstrated reasonable competence in basic number systems, significant gaps were observed in algebraic reasoning, geometry, and the application of mensuration concepts. These results have important implications for mathematics teaching and student learning outcomes in the district.

Interpretation of Findings

The moderate performance overall indicates that teachers possess foundational knowledge but lack depth in higher-order concepts. Weaknesses in algebra and geometry echo earlier research in India (NCERT, 2019), where teachers frequently struggle with abstract reasoning and proof-based tasks. This study confirms that such deficiencies persist in rural districts like Nayagarh, potentially undermining efforts to foster conceptual understanding among students.

The comparative analysis further revealed disparities across school types and locations. Private and semi-urban school teachers outperformed their government and rural counterparts, suggesting that contextual factors such as resource availability, exposure to professional development, and institutional support play a role in shaping teacher CK. This aligns with Ball, Thames, and Phelps (2008), who emphasize that effective teaching is not only about individual knowledge but also about systemic support structures.

Alignment with Existing Literature

The findings corroborate Shulman's (1986) assertion that content knowledge forms the foundation of pedagogical practice. Teachers with limited mastery cannot scaffold learning effectively, leading to reliance on rote instruction — a pattern observed in classroom observations in this study. Similarly, Hill, Rowan, and Ball (2005) established

that teacher subject knowledge is a strong predictor of student achievement; the current study reinforces this relationship in the context of Odisha.

Odisha's ASER reports also note deficiencies in both teacher preparedness and student outcomes in mathematics. This case study thus adds empirical evidence specific to Nayagarh district, highlighting that teacher CK deficits are a localized manifestation of a broader systemic challenge in Indian mathematics education.

Implications for Policy and Practice

The evidence underscores the urgent need for continuous professional development tailored to mathematics content. In-service training programs must go beyond general pedagogy to address domain-specific gaps, particularly in algebra and geometry. Moreover, mentoring systems and peer-learning models can provide sustained support, enabling teachers to update their knowledge regularly.

The study also suggests that resource disparities between government and private schools must be addressed. Equitable access to teaching-learning materials, refresher courses, and ICT-based resources can help rural and government school teachers bridge knowledge gaps.

Limitations and Future Research

While this study provides valuable insights, it is limited by its focus on a single district, which may constrain generalizability. The sample size, though adequate for district-level analysis, does not capture statewide diversity. Future research could expand to multiple districts in Odisha and employ longitudinal designs to examine how teacher CK evolves over time with interventions. Additionally, studies could explore the link between teacher CK and actual student performance data in greater detail.

CONCLUSION

This study set out to assess the mathematics content knowledge of upper primary school teachers in Nayagarh district of Odisha. The findings highlight that while teachers possess adequate understanding of basic mathematical concepts, significant weaknesses exist in algebraic reasoning, geometry, and application-based problem-solving. These gaps are particularly evident among teachers from government and rural schools, pointing to systemic inequities in access to professional development and teaching resources.

The study confirms that teacher content knowledge plays a decisive role in shaping the quality of classroom instruction and, consequently, student performance in mathematics. Where teachers demonstrated stronger mastery, classroom practices were more engaging and students were provided with greater opportunities for conceptual learning. Conversely, in cases where teachers lacked confidence in mathematics content, lessons relied heavily on rote methods, limiting deeper student understanding.

Overall, the research underscores the urgent need for targeted professional development programs that focus not only on pedagogy but also on strengthening mathematics content knowledge. District-level interventions such as refresher courses, peer mentoring, and content-focused workshops could help bridge the identified knowledge

gaps. Furthermore, ensuring equitable support for government and rural school teachers is essential for improving learning outcomes across the district.

By situating the findings within broader research and educational policy frameworks, the study contributes evidence that can guide teacher training reforms in Odisha and beyond. Addressing teacher content knowledge is not merely a matter of academic development but a crucial step toward improving mathematics education and ensuring that all students acquire the skills necessary for logical reasoning, problem-solving, and lifelong learning.

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