TEACHERS' COLLABORATION AS AN EMERGING MATHEMATICS TEACHING STRATEGY IN SOUTH AFRICA: A MODEL FOR PROFESSIONAL DEVELOPMENT

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ABSTRACT

This study proposes a Collaborative Professional Development Model to address the persistent underperformance in secondary school mathematics in South Africa. Despite significant financial investment, the education system remains characterised by stark inequalities, inadequate infrastructure, underqualified educators, and poor learner outcomes, particularly in mathematics. The research, situated within a social constructivist paradigm, employed a concurrent triangulation mixed-methods design within a case study of the Centocow cluster in KwaZulu-Natal. Data from 5 educators, 2 subject advisors, and 20 Grade 10 learners were collected via diagnostic tests, questionnaires, semi-structured interviews, focus groups, and classroom observations. Findings confirm critical deficiencies in educators' Pedagogical Content Knowledge (PCK), prevalent negative attitudes towards mathematics ("mathophobia"), and a reliance on traditional, teacher-centred pedagogies. In response, the study designed and refined a context-sensitive Collaborative Model. This model advocates for structured, ongoing professional learning communities where educators, supported by subject advisors and school management, engage in co-planning, team teaching, resource sharing, and reflective practice. The model positions collaboration not as an optional add-on but as a fundamental strategy for building collective capacity, demystifying mathematics, and improving instructional quality. The article concludes that systemic adoption of such collaborative networks, aligned with the National Development Plan's vision, is essential for transforming mathematics education and achieving equitable, quality outcomes in South African secondary schools.

Keywords: Mathematics Education; Teacher Collaboration; Professional Development; South Africa; Pedagogical Content Knowledge; Social Constructivism; Underperformance.

1. INTRODUCTION

The state of mathematics education in South Africa presents a profound paradox. While the post-apartheid government has prioritised education, allocating a substantial portion of the national budget approximately 20% in 2015, surpassing the OECD average (World Bank, 2018) the return on this investment, measured by learner outcomes, remains critically low. International benchmark studies consistently place South Africa at or near the bottom in mathematics performance (Reddy et al., 2016; Mullis et al., 2016; Spaull, 2019). This crisis undermines national goals for economic development, innovation, and social equity as outlined in the National Development Plan 2030 (National Planning Commission, 2012).

The challenges are systemic and multifaceted. Research highlights extreme inequalities in resource distribution, with many schools, particularly in rural and township areas, lacking basic infrastructure, libraries, and laboratories (Department of Basic Education, 2018). Beyond physical resources, the quality of teaching is a pivotal concern. Studies indicate that a significant proportion of mathematics teachers, especially in under-resourced schools, possess insufficient subject content knowledge, sometimes at levels below the curriculum they are expected to teach (Spaull, 2013; Carnoy et al., 2011). This is compounded by high rates of teacher absenteeism, low levels of professional motivation, and accountability mechanisms (Van der Berg et al., 2011; Mbiti, 2016).

Pedagogical practices in many mathematics classrooms remain entrenched in traditional, transmissive methods characterised by chalk-and-talk, rote memorisation, and teacher-dominated discourse (Makondo & Makondo, 2020; Festus, 2013). This approach often fails to engage learners, fosters anxiety, and neglects the development of conceptual understanding and problem-solving skills. Consequently, learner performance is poor, dropout rates are high, and a culture of low expectations becomes endemic, particularly in historically disadvantaged communities (Taylor & Reddy, 2013).

In response to these persistent challenges, this study argues for a paradigm shift from isolated, individualised teaching towards structured, professional collaboration as a core strategy for improvement. While various intervention programmes have been implemented, their impact has often been limited by a top-down, fragmented approach that does not sufficiently empower teachers as agents of change (Fullan, 2001). This article posits that sustainable improvement requires building professional learning communities within and across schools. The study therefore aimed to develop, design, and construct a contextually relevant Collaborative Model for teaching and learning mathematics in secondary schools. The model is grounded in the principles of social constructivism (Vygotsky, 1978) and professional network theory (Bryk et al., 2010), emphasising that knowledge and effective practice are socially constructed through sustained interaction, dialogue, and shared purpose among stakeholders.

The research was guided by the central question: What processes and activities can be used to construct a Collaborative model for teaching and learning Mathematics in secondary schools? It further explored the factors contributing to low performance, potential collaborative intervention strategies, and the conditions necessary for effective implementation.

2. LITERATURE REVIEW

2.1 The Crisis in South African Mathematics Education

The depth of the challenge in South African mathematics education is well-documented. South African learners consistently perform poorly in international assessments like the Trends in International Mathematics and Science Study (TIMSS). In TIMSS 2015, South Africa ranked among the lowest-performing countries, with an average score of 372 for Grade 9 mathematics (Mullis et al., 2016). National Senior Certificate results, while showing some fluctuation, reveal that on average, nearly half of all learners who attempt mathematics fail the subject (DBE, 2020). This underperformance is not evenly distributed but is heavily skewed along socio-economic lines, reproducing historical inequalities (Spaull, 2013).

A critical factor identified in the literature is the variable quality of teachers. Investigations into teacher competency reveal alarming gaps. For instance, the SACMEQ III (2007) study found that many Grade 6 mathematics teachers in quintile 1-3 schools had content knowledge levels comparable to or lower than teachers in neighbouring lower-income countries (Spaull, 2013). Furthermore, teacher absenteeism and limited "time-on-task" significantly reduce actual teaching hours, directly impacting learning opportunities (Van der Berg et al., 2011; Reddy et al., 2010).

2.2 The Limitations of Traditional Professional Development

Traditional models of teacher professional development (TPD) in South Africa have often been criticised as ineffective. These are frequently characterised by one-off, top-down workshops that are disconnected from classroom realities, lack follow-up support, and fail to address teachers' specific contextual needs (Guskey, 2002; Desimone, 2009). Such approaches rarely lead to sustained changes in pedagogical practice. Bertram (2011) notes that constant curriculum changes and superficial training sessions may contribute to teacher despondency and underperformance rather than empowerment.

2.3 Collaboration as a Professional Development Strategy

In contrast, collaborative models of professional development offer a promising alternative. Rooted in social constructivist theory, these models posit that learning is a social activity where knowledge is constructed through interaction (Vygotsky, 1978). Applied to teachers, this means that professional growth is most effective when it occurs within communities of practice where educators collectively engage in reflective dialogue, lesson study, peer observation, and joint problem-solving (Wenger, 1998; Darling-Hammond et al., 2017).

Research supports the efficacy of collaboration. Teacher collaboration has been linked to increased teacher self-efficacy, the adoption of innovative pedagogies, and improved student achievement (Goddard et al., 2007; Vangrieken et al., 2015). In the context of mathematics, collaborative practices such as co-planning, analysing student work, and team teaching can help demystify complex content, share successful instructional strategies, and build a shared responsibility for learner success (Horn & Little, 2010).

Collaboration can take various forms, from informal peer support within a school to structured professional learning communities (PLCs) and subject-based clusters across schools (Stoll et al., 2006). Cook and Friend (1996) outline models like team teaching, parallel teaching, and station teaching, which can be adapted for professional development purposes. The key elements of successful collaboration include voluntary participation, shared goals, mutual trust, parity among participants, and the availability of time and institutional support (Little, 1990; Hargreaves, 1994).

2.4 The South African Context and the Gap

While the international literature advocates for collaboration, its systematic implementation within the specific, resource-constrained, and historically fragmented context of South African schools remains underexplored. Studies often identify problems but stop short of proposing detailed, actionable models for collaborative TPD that are sensitive to local conditions, such as large class sizes, variable teacher qualifications, and geographical isolation of rural schools. This study seeks to fill this gap by developing a grounded, context-specific Collaborative Model derived from empirical data collected in a typical rural South African setting.

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3. METHODOLOGY

3.1 Research Design and Paradigm

This study employed a pragmatic research paradigm, utilizing a concurrent triangulation mixed-methods design (Creswell & Plano Clark, 2018) embedded within an instrumental case study approach (Stake, 1995; Yin, 2018). The case study focused on the Centocow cluster, a rural educational circuit in the Sisonke District of KwaZulu-Natal. This design allowed for the simultaneous collection of quantitative and qualitative data to provide a comprehensive understanding of the factors affecting mathematics teaching and learning, and to inform the development of the Collaborative Model.

3.2 Participants and Sampling

A purposive sampling technique was used to select participants who could provide rich, relevant information. The sample consisted of:

Five (5) Grade 10 Mathematics teachers (one from each of five secondary schools in the cluster).

Two (2) Mathematics Subject Advisors responsible for the circuit.

Twenty (20) Grade 10 Mathematics learners (four randomly selected from each of the five schools, stratified by gender).

3.3 Data Collection Instruments and Procedures

Data were collected concurrently using multiple instruments to ensure triangulation and depth:

1. Diagnostic Performance Test: Adapted from TIMSS items, a 64-mark test was administered to both teachers and learners to benchmark content knowledge.
2. Questionnaires: Structured and semi-structured questionnaires were used with teachers and subject advisors to gather data on qualifications, experience, pedagogical beliefs, attitudes towards mathematics, and perceptions of challenges and possible interventions.
3. Semi-structured Interviews: In-depth interviews were conducted with the five teachers to explore their teaching practices, beliefs, and views on collaboration.
4. Focus Group Interviews: Five focus group discussions were held with the learner groups to understand their classroom experiences, attitudes, and suggestions.
5. Classroom Observations: Non-participant observations were conducted in each teacher's classroom using a structured checklist to document pedagogical approaches, learner engagement, and use of resources.

3.4 Data Analysis

Quantitative data (test scores, questionnaire Likert scales) were analysed using descriptive statistics (means, frequencies, percentages) and inferential statistics (t-tests, correlation analysis) with SPSS software. Qualitative data (interview and focus group transcripts, observation notes) were analysed using thematic analysis (Braun & Clarke, 2006). The process involved familiarisation, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. Data integration occurred during the interpretation phase, where quantitative and qualitative findings were merged to provide a coherent understanding of the research problem (Fetters et al., 2013).

3.5 Ethical Considerations

Ethical clearance was obtained from the University of South Africa and the provincial Department of Education. Informed consent was secured from all participants. Anonymity and confidentiality were maintained through the use of pseudonyms for schools and participants. Participation was voluntary, with the right to withdraw at any time.

4. RESULTS

The integrated analysis of the data revealed several key themes that directly informed the construction of the Collaborative Model.

4.1 Deficiencies in Pedagogical Content Knowledge (PCK)

The diagnostic test results exposed significant gaps. The average learner score was 14.15% (SD=63.92), with 75% of learners failing (scoring below 30%). While teachers performed better (average 26%), the highest teacher score (59%) was surpassed by the highest learner score (64%). A positive correlation was found between teacher and learner scores in their respective schools (see Fig. 6.4, original thesis). Classroom observations corroborated this; teachers often struggled with in-depth concept explanations, relied heavily on textbook examples, and made procedural errors during instruction. This aligns with Spaull's (2013) findings on teacher content knowledge.

4.2 Prevalence of Traditional Pedagogies and Low Learner Engagement

Observations and interview data confirmed that teacher-centred, chalk-and-talk methods dominated 80% of the classrooms observed. Lessons were characterised by routine procedures, minimal learner participation, and a focus on memorisation over conceptual understanding. Focus group learners reported feeling passive, scared to ask questions, and confused during lessons. Teachers attributed low engagement to learner "apathy" and lack of "mathematical giftedness," revealing a deficit perspective.

4.3 Negative Attitudes and Mathophobia

Both quantitative and qualitative data highlighted pervasive negative attitudes. In questionnaires, 89% of learners and 80% of teachers expressed anxiety and a lack of confidence in mathematics. Teachers described feeling "uncomfortable" and "frustrated," while learners reported "dreading" the subject. This "mathophobia" was identified as a major barrier to effective teaching and learning.

4.4 Systemic Challenges and Isolation

Teachers cited numerous systemic challenges: inadequate textbooks (shared 1:3 or 1:4), constant curriculum changes, lack of parental support, and insufficient supervisory visits from subject advisors. A strong sense of professional isolation emerged; teachers reported working in "silos" with little opportunity to share challenges or successful strategies with colleagues from other schools.

4.5 Strong Endorsement for Collaborative Solutions

When asked about potential solutions, there was unanimous (100%) support from teachers and subject advisors for structured collaboration. Suggested activities included:

- Regular cluster-based workshops focused on content and pedagogy.
- Joint planning and development of assessment tasks.
- Peer observation and team teaching across schools.
- Creating and sharing a common bank of resources and lesson plans.
- Establishing professional learning communities for ongoing support.

Learners also advocated for more collaborative learning in their classrooms, suggesting group work, peer teaching, and project-based tasks to make mathematics more engaging and understandable.

5. DISCUSSION: CONSTRUCTING THE COLLABORATIVE MODEL

The findings provided the empirical foundation for refining the theoretically conceived Collaborative Model (initially based on Loucks-Horsley et al., 1998). The final model (Fig. 6.9, original thesis) is a dynamic system with the following core components and processes:

5.1 Core Stakeholders and Their Roles

The model expands the network of responsibility beyond the individual teacher to include:
Mathematics Educators: The primary agents, engaged in peer learning, resource sharing, and reflective practice.
Learners: Active participants in collaborative classroom activities (group work, projects, peer assessment).
Subject Advisors: Transform from inspectors to facilitators and coaches, organising cluster workshops and providing ongoing instructional support.
Heads of Department/ School Management: Provide institutional support, timetable collaboration time, and foster a school culture conducive to professional learning.
Parents/Guardians: Engaged as partners to support learning at home, monitor homework, and reinforce positive attitudes.

5.2 Key Processes and Activities

The model proposes a cycle of collaborative activities:
1. Needs-Driven Cluster Workshops:Regular (e.g., fortnightly or monthly) meetings where teachers, guided by subject advisors, collaboratively address content gaps, explore learner-centred pedagogies (e.g., problem-based learning, manipulatives), and moderate learner work.
2. Co-Development of Resources: Collaborative creation of a standardised "Study and Teaching Guide" that integrates PCK, lesson activities, and assessment tasks tailored to the local context.
3. Peer Observation and Team Teaching: Structured opportunities for teachers to observe each other, engage in co-teaching models (Cook & Friend, 1996), and provide constructive feedback.
4. Joint Assessment Design and Analysis: Teachers collectively design common assessment tasks and analyse results to identify common learner errors and plan targeted interventions.

5. Establishing Professional Learning Communities (PLCs): Moving beyond ad-hoc workshops to sustained, school-based PLCs where teachers continuously inquire into their practice, supported by the wider cluster network.

5.3 Essential Enabling Conditions

For the model to succeed, the study identified critical conditions:
Structured Time: Dedicated, timetabled time for collaboration must be formally allocated and protected.
Supportive Leadership: School and district leadership must actively champion and resource the collaborative process.
Trust and Psychological Safety:A culture of mutual respect and trust, where teachers feel safe to share weaknesses and experiment without fear of judgement, is fundamental.
Shared Vision and Goals: All stakeholders must commit to the common goal of improving mathematics outcomes through collective effort.
Adequate Resources: Provision of basic teaching materials and access to meeting spaces is a non-negotiable foundation.

5.4 Addressing the Identified Challenges

The model is designed to directly counteract the findings:
PCK Deficits:Addressed through content-focused collaborative workshops and peer knowledge sharing.
Traditional Pedagogy: Challenged by exposing teachers to and jointly planning alternative, learner-centred strategies.
Mathophobia: Mitigated by creating a supportive professional community that boosts teacher confidence, which cascades to learners. Collaborative, engaging classroom activities reduce learner anxiety.
Professional Isolation:Eradicated by building formal and informal networks of support.
Systemic Neglect: Countered by fostering collective agency among teachers and creating a structured channel for requesting and utilising advisory support.
This Collaborative Model aligns with international best practices in TPD (Darling-Hammond et al., 2017) while being firmly grounded in the realities of the South African rural school context. It moves away from deficit-based interventions towards a strengths-based, capacity-building approach that leverages the collective expertise within the system.

6. CONCLUSION AND IMPLICATIONS

This study confirms that the crisis in South African mathematics education is rooted in interconnected issues of teacher competency, pedagogical practice, and systemic support. It demonstrates that isolated teachers working in under-resourced environments are ill-equipped to reverse the trend of underperformance. In response, the research articulates a viable alternative: a structured, context-sensitive Collaborative Model for teacher professional development.

The proposed model is not merely a theoretical construct but an empirically informed framework for action. It offers a practical pathway for districts and schools to operationalise the National Development Plan's call for "highly motivated teachers" and "effective principals" (NPC, 2012, p. 30). By fostering professional learning communities, the model has the potential to build sustainable internal capacity, improve the quality of classroom instruction, and ultimately enhance learner achievement in mathematics.

6.1 Implications for Policy and Practice

For the Department of Basic Education:Policy should formally mandate and resource structured collaboration time within teachers' working hours. Teacher appraisal and school evaluation frameworks should recognise and incentivise collaborative professional activities.
For District Officials and Subject Advisors:Their role must evolve from compliance monitoring to that of curriculum facilitators and lead learners. They should be trained to establish and sustain cluster-based professional learning networks.
For School Leadership: Principals and HODs must be developed as instructional leaders who create a school culture that values collaboration, provides time for it, and protects teachers from administrative overload to engage in it meaningfully.
For Teacher Education Institutions:Pre-service and in-service programmes should incorporate training in collaborative skills, peer coaching, and participation in professional learning communities.

6.2 Limitations and Recommendations for Future Research

This study was a small-scale, in-depth case study in a rural setting. While it provides a rich, contextualised model, its generalisability to urban or more affluent contexts may be limited. The model was designed and refined based on baseline data but requires empirical testing to evaluate its impact on teacher practices and learner outcomes over time.

Future research should therefore focus on:

1. Implementing and longitudinally evaluating the refined Collaborative Model in diverse contexts (rural, township, suburban).
2. Investigating the specific leadership practices that most effectively enable and sustain teacher collaboration.
3. Exploring the role of digital technology in facilitating collaboration among geographically dispersed teachers in South Africa.

In conclusion, transforming mathematics education in South Africa requires moving beyond short-term interventions and investing in the long-term professional capital of teachers. This study argues that fostering systematic, meaningful collaboration is not just an emerging strategy but a necessary foundation for building a more equitable and effective education system. The Collaborative Model presented provides a blueprint for turning this imperative into actionable practice.

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