THE PEDAGOGICAL NEXUS IN TEACHING ELECTRICITY CONCEPTS IN THE GRADE 9 NATURAL SCIENCES AND TECHNOLOGY CLASSROOM

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ABSTRACT

This study examines the pedagogical approaches employed by Grade 9 Natural Sciences (NS) and Technology (Tech) teachers when teaching electricity concepts in South African classrooms, in KwaZulu Natal. Research indicates that learners' conceptual understanding and misconceptions of electricity directly correlate with teaching quality and teachers' pedagogical content knowledge. The study explores how the pedagogical practices across both subject's impact student learning, to identify strategies for teaching these cross-cutting concepts and improve electricity education outcomes. Mavhunga's Topic Specific Pedagogical Content Knowledge framed this study theoretically. Data was generated using individual interviews, lesson observations and document analysis. Participants were purposively selected. The finding illustrates a clear nexus in teachers' pedagogical practices when teaching electricity in Natural Sciences (NS) and Technology at the Grade 9 level. This connection manifests through multiple teaching strategies, including chalk-and-talk, discussions, demonstrations, hands-on activities, projects, and digital technologies such as simulations and YouTube videos.

KEYWORDS

Electricity, natural sciences, technology, pedagogy, nexus

1. INTRODUCTION

Technology and Science represent interconnected domains of knowledge that continuously enhance and inform each other. The Curriculum Assessment Policy Statements [1] in the South African context stress that teaching NS and Tech necessitates making explicit links between linked subjects in order to improve students' understanding and capacity to apply these ideas to their daily lives. Electricity represents one such crucial intersection between these disciplines, introduced in Grades 4-6 as an integrated subject NS-Tech (Intermediate Phase) and expanded upon in Grades 7-9 (Senior Phase) as distinct subjects, that is, as Technology (Tech) and Natural Science (NS). The argument put forth in this paper is that the pedagogical approaches employed in teaching electricity concepts in the Grade 9 Natural Sciences and Technology classroom create a critical nexus and foundation for learners' conceptual understanding (or misconceptions) of electricity in higher grades. Research indicates that learners' conceptual understanding of electricity and misconceptions correlate with teaching quality and teachers' pedagogical content knowledge [2, 3]. These misconceptions arise from how electricity is taught to learners. Each NS and Tech teacher, intentionally or unintentionally, creates, shapes, and enacts the gazetted curriculum, which encompasses explicitly and implicitly [4]. They tailor and convey their unique perspectives and initiatives to learners through their teaching styles and pedagogical approaches. As a result, the curriculum that learners experience - known as the achieved curriculum - may differ from the gazetted curriculum [4].

Moodley [5] emphasises that electricity concepts are particularly challenging due to their abstract nature and complexity, making them pedagogically demanding. The cross-cutting concepts of electricity in NS and Tech require careful consideration of teaching approaches and thorough teacher preparation. Recent studies examining the teaching of electric circuits globally and locally have revealed significant challenges in this domain [2, 3, 6]. Researchers consistently identify electric circuits as an abstract topic that presents substantial teaching and learning challenges [7]. The study of [8] and [9] shows how South African grade 9 learners struggle to perform well in international benchmarking exams, such as Trends in International Mathematics and Science Study (TIMSS), particularly in electricity-related questions. Thus, it is key to get more insight into the way in which the topic on electricity, is taught in both NS and Tech in Grade 9 classrooms.

Studies [3, 5] have attempted to shed light on NS teachers' pedagogical content knowledge (PCK) on electricity. While research has examined NS and Tech teaching practices separately, a notable gap exists in understanding the nexus between these approaches—particularly how similarities, differences, and gaps in pedagogical practices across these subjects' impact student learning. The present study addresses this gap by exploring both NS and Tech teachers' pedagogical approaches to teaching electricity and examining the nature of the nexus between these practices. Exploring the pedagogical practices used to teach these cross-cutting concepts in NS and Tech can provide valuable deeper insights into the strategies or nexus employed to facilitate learning for diverse learners. The nexus also highlights similarities in pedagogical approaches to teaching electrical concepts, identifying teaching method differences and recognising knowledge construction gaps. Based on the identified challenges and the importance of the pedagogical nexus in electricity education, this study explores:

What pedagogies do Grade 9 NS and Tech teachers employ when teaching electricity?
How does the pedagogical practice of the Grade 9 NS and Tech teachers impact their electricity teaching?
Through addressing these questions, this research contributes meaningfully to our understanding of how electricity education can be improved at this crucial stage of learners' educational journey.

2. Literature Review

This literature review examines current research on pedagogical approaches in teaching electricity, cross-curricular connections, subject-specific PCK,

Traditional versus Constructivist Approaches

Research on pedagogical approaches to teaching electricity reveals a tension between traditional and constructivist methodologies. Duit and von Rhöneck [10] argue that traditional, teacher-centred approaches often fail to address preconceptions that students bring to electricity lessons. This results in fragmented understanding when teachers employ lecture-based instruction without practical application. In contrast, constructivist approaches that build on students' prior knowledge and encourage active exploration show more promising results in developing conceptual understanding [11].

Moodley and Gaigher [2] found that 67% of observed Grade 9 NS lessons in South Africa were predominantly teacher-centred, with limited practical investigations or conceptual discussion opportunities. Similarly, [12] observed that Tech teachers, while more likely to incorporate hands-on activities, often failed to connect these activities to underlying scientific principles.

Inquiry-Based Learning and Practical Work

Research consistently demonstrates that inquiry-based learning approaches yield positive outcomes for teaching electricity concepts. Mji and Makgato [13] (2006) show that authentic investigation and problem-solving significantly improve students' conceptual understanding of electricity. Nemadziva et al. [14] found guided inquiry approaches—where teachers provide structured support while allowing student exploration—particularly effective in South Africa.

However, implementation varies significantly. Ramnarain et al, [11] noted divergences in inquiry-based learning utilization, especially in disadvantaged communities lacking resources and teacher training. Kim et al [15] observed that while CAPS curriculum documents advocate for inquiry-based approaches, implementation varies widely based on school resources and teacher preparation.

Onder et al [16] found that practical work yields significant benefits in technology classrooms, though many Tech teachers struggle to connect practical activities with theoretical concepts, creating disconnects that hamper student understanding.

Cross-Curricular Connections

Despite the curricular overlap in electricity concepts between NS and Tech, research suggests limited teacher coordination. Singh-Pillay and Alant [17] found minimal evidence of deliberate cross-curricular planning or alignment, with teachers rarely discussing cross-curricular connections and students seldom encouraged to transfer knowledge between subjects.

Poti [3] examined how conceptual frameworks for electricity differ between NS and Tech curricula, revealing significant opportunities for strengthening the nexus through coordinated teaching approaches. While NS focuses on conceptual understanding of electrical principles, Tech emphasizes application and design—creating complementary rather than redundant learning opportunities.

Zulu [6] investigated coordinated teaching strategies across NS and Tech, finding that student misconceptions dropped by 32% when teachers actively cooperated and aligned their instructional techniques compared to control groups, highlighting the potential benefits of pedagogical connections.

Subject-Specific Pedagogical Content Knowledge (PCK)

Kind [18] established that effective science teaching requires specialized pedagogical content knowledge—the unique blend of content knowledge and pedagogical knowledge specific to teaching particular subjects. Rollnick et al. [19] investigated South African NS teachers' PCK regarding electricity concepts, identifying significant gaps in how teachers conceptualize and represent electrical concepts, particularly circuit analysis and energy transformation.

For Tech teachers, Mapotse [20] found that PCK often emphasizes procedural knowledge over conceptual understanding, with teachers frequently focusing on helping students complete practical tasks without sufficient attention to underlying principles. Basitheva [21] notes that teacher preparation programs in South Africa often separate NS and Tech methodologies, reinforcing the pedagogical divide students experience.

Challenges in Teaching Electricity Concepts

Abstract Nature and Conceptual Difficulties

Electricity presents particular challenges due to its abstract nature. Quezada-Espinoza et al [2023] identified persistent conceptual difficulties, including confusion between current and voltage, misconceptions about complete circuits, and difficulties understanding parallel and series connections.

Gaigher [7] found that language barriers and limited resources in South African classrooms exacerbate these difficulties. South Africa has a multilingual learning environment. Learners who are taught in languages other than their home language or mother tongue face extra difficulties comprehending abstract terms or concepts on electricity.

Resource Limitations and Implementation Challenges

Resource limitations constrain practical pedagogical approaches. Oguoma et al [2019] found that 63% of surveyed South African schools lacked adequate equipment for electricity experiments. Teachers struggle to implement effective practical activities without basic resources like batteries, bulbs, and wires. Maimela [9] highlights time constraints as additional challenges. Teachers frequently report insufficient time to cover electricity concepts with the required depth for conceptual understanding, leading to didactic approaches focused on examination preparation rather than deep conceptual development.

Impact on Student Understanding and Misconceptions

Research documents numerous persistent misconceptions, including beliefs that current is consumed in circuits, that batteries provide constant current regardless of configuration, and confusion about current flow direction [24]. Moodley [5] found these misconceptions persist through Grade 9 into higher grades, becoming increasingly resistant to change if not addressed early.

Critically, teacher pedagogical approaches directly influence misconception formation and persistence. Shen et al. [25] demonstrated that teacher-centred approaches emphasizing memorization over conceptual understanding tend to reinforce rather than resolve electricity misconceptions. Poti [3] found that misconceptions solidify when educators fail to address prevalent misunderstandings or provide opportunities for students to assess their comprehension through hands-on research, highlighting the importance of deliberate pedagogical strategies.

3. THEORETICAL FRAMEWORK

This study employs Topic Specific Pedagogical Content Knowledge (TSPCK) as its theoretical framework to examine pedagogical approaches Natural Sciences and Technology teachers use when teaching electricity concepts in Grade 9 classrooms.

TSPCK represents a refinement of [26, 27] work, recognizing that teaching knowledge is highly contextualized and specific not only to subjects but to particular topics within those subjects. As articulated by [28], this specificity is crucial because different topics present unique conceptual challenges requiring distinct pedagogical approaches. In South Africa, TSPCK has gained

significant traction in science education research, with studies by [29, 11] demonstrating its utility in examining teachers' knowledge development and classroom practices.
TSPCK comprises five interrelated components representing a teacher's capacity to transform subject matter knowledge into learner-accessible forms:

Learner Prior Knowledge

How teachers identify, assess, and address students' existing understanding of electricity concepts, including common misconceptions about current flow, circuit connections, and energy transformation.

Curricular Saliency

Teachers' ability to identify and prioritize core electricity concepts, recognize their curriculum sequencing, and understand relationships to broader disciplinary themes, such as ensuring foundational circuit principles precede complex ideas like Ohm's law.

What Makes the Topic Difficult

Teachers' awareness of electricity's conceptual challenges, particularly its abstract nature, invisible processes, and counter-intuitive principles that learners typically find challenging.

Representations

The analogies, models, and demonstrations teachers use to make abstract electricity concepts accessible, including physical circuit models, water flow analogies, or computer simulations of electron movement.

Teaching Strategies

Specific instructional approaches addressing known difficulties and misconceptions, such as inquiry-based investigations, predict-observe-explain sequences, or structured practical work.

TSPCK offers several advantages for examining the nexus between Natural Sciences and Technology pedagogical practices. It provides a structured lens for analyzing how teachers transform electricity understanding into pedagogically effective forms, acknowledges content-specific pedagogical knowledge requirements, and enables comparison of practices across subjects to identify alignment or disconnection areas. The framework's emphasis on learner prior knowledge directly addresses how pedagogical approaches influence conceptual understanding, while its extensive development in South African science education research enhances its contextual relevance within the CAPS curriculum framework.

4. METHODOLOGY

This qualitative study adopted an interpretative paradigm and case study design to understand Grade 9 Natural Sciences and Technology teachers' experiences of teaching electricity concepts. The study sought to explore the subjective world of teachers' pedagogical practices and derive meaning from their shared experiences.

Six teachers from three schools in the Eshowe circuit of King Cetshwayo district participated in this study. Selection criteria required participants to teach Natural Sciences, Technology, or both subjects at the Grade 9 level. The sample comprised two teachers per school, with varying subject combinations across the three schools.

Data Collection Multiple data collection methods were employed following ethical approval (HSSREC 00006716/2024):

Individual Interviews

Thirty-minute audio-recorded interviews explored teachers' pedagogical approaches, reasons for method selection, activity design, complex concepts, awareness of learner misconceptions, prior knowledge assessment, and misconception rectification strategies.

Lesson Observations

Each teacher was observed during two electricity lessons, totalling twelve observations. An observation schedule examined lesson structure, teaching methods, and overall impressions. All observations were audio-recorded and transcribed verbatim.

Post-observation Interviews: Conducted after each lesson to gain deeper insights into teachers' pedagogical choices and explore observed teaching practices further.

Document Analysis

Teaching portfolios were analyzed to examine pedagogical approaches, planned learner activities, and assessment methods used in electricity instruction.

Audio recordings were transcribed verbatim and assigned pseudonyms (P1-P6). Interview transcripts underwent multiple reviews and coding based on the study's conceptual framework constructs. An "open-coding" approach was adopted, using line-by-line and phrase-by-phrase techniques to identify standardized remarks and group them into sections. Concepts were derived from collected data, with codes subsequently regrouped into themes for analysis.

Table 1 Themes

Pedagogy Employed	Number of Teachers	Categories: *Impact of the Pedagogies used*	Themes
Chalk-and-Talk (drawings on board/charts) Discussion, jigsaw, think- pair-share methods Demonstrations, hands-on activities, project	**P1, P3, P5**	• Promotes conceptual understanding • Scaffolds learning • Addresses learner misconceptions • Fosters learners' collaboration and verbal communication skills	**Promotes conceptual learning, Collaboration**
Demonstrations, hands-on activities, projects Discussion, jigsaw, think- pair-share methods	**P2, P3, P1, P6**	• Promotes problem-solving and critical thinking skills • Provides experiential / hands-on learning,	**Promote**
Digital technology (simulations and YouTube videos)	**P6**	• Develops process skills (NS) and promotes creativity (Tech)	

5. FINDING AND DISCUSSION

Chalk-and-Talk

Two teachers employed traditional chalk-and-talk methods, using chalkboards and charts to explain electricity concepts. During the interview a participant mentioned "*I rely on the chalkboard to get learner to make sense of concepts that are difficult and abstract like atoms, charges, resistance"* (P1 interview). This approach allows visual demonstration of electrical principles and circuits. Using chalkboards remains well-established in science education [30] with research suggesting that diagrams help students develop mental models of electrical systems [31].

However, classroom observations revealed significant limitations. Lessons were predominantly teacher-centred with minimal learner participation: *"That learner participation was minimal during the lesson, and the lesson was very teacher-centred"* (P1 observation). While this pedagogy effectively utilises 'teachers' content knowledge and makes abstract concepts concrete through visual representations, it has notable drawbacks. Research demonstrates that traditional chalk-and-talk methods inadequately address electricity misconceptions and fail to promote deeper conceptual understanding when applying circuit laws [32]. This contrasts with East Asian contexts where similar methods yield success in international assessments like TIMSS and PIRLS [33], suggesting cultural and contextual factors influence traditional teaching effectiveness.

Discussion, Jigsaw, Think-Pair-Share Strategies

Three participants employed direct instruction with facilitated discussions, jigsaw, and think-pair-share methods to teach electricity concepts. These interactive strategies allow teachers to explain key ideas while engaging students in dialogue to check understanding.

P3 described using discussions and think-pair-share for resistance concepts: *" I use discussions, jigsaw, think-pair-share, and other interactive approaches when teaching electricity. For instance, when teaching resistance and the variables that affect it, I employ think-pair-share, which involves learners brainstorming in pairs and then using real-world examples to discuss the factors and how they affect resistance".*

P4 implemented structured problem-solving approaches: *"In my teaching of electricity, I let learners analyse a problem on circuits, alone, then I ask them to share with the person seated alongside them their solution and reasoning, thereafter the pair share their consolidated understanding to the class. I have noted that this improves learners' confidence in presenting ideas, reasoning, problem-solving skills, and conceptual understanding."*

P5 utilised jigsaw methods for complex concepts: *"I have tried discussions and jigsaw methods for teaching electricity, for example, Ohm's Ohm's law concepts by breaking them into manageable components. In this approach, learners are first grouped into "expert" teams, each focusing on different aspects of circuit analysis, and then they move between groups to share their ideas; this is an easy way to identify misconceptions."*

These discussion strategies effectively reveal and address learner misconceptions. P3 noted: *"During these discussions, learners are forced to think, predict, and explain how changing resistance affects current flow."* Each teacher employed different approaches: P5 facilitated class discussions to identify misconceptions, P3 provided varied activities with correction sessions, and P4 linked concepts to real-life situations and considered learners' background knowledge. These findings align with those of [34],which mentioned that teacher-led conversations about series and parallel circuits help students express logic about voltage distribution and current flow. Deeper conceptual understanding and active involvement are encouraged by interactive teaching approaches [35].

Chen and Thompson [32] found that learners participating in regular classroom discussions about electrical concepts exhibited improved problem-solving abilities compared to those taught using traditional methods alone.

Research by [31] demonstrated that learners taught using jigsaw methods showed 35% improvement in complex circuit analysis abilities. Thompson et al. [36] found that utilising multiple strategies—think-pair-share for prior knowledge activation, jigsaw grouping for concept exploration, and whole-class discussion—successfully enhanced students' circuit analysis capabilities while addressing various learning styles and providing concept reinforcement opportunities.

Demonstrations, Hands-on Activities, Projects

Four teachers employed practical demonstrations, experiments, and project-based learning to address electricity's abstract nature. P2 explained: *"Because some concepts are abstract, practical work is important when teaching the topic of electricity- it helps learners to understand these concepts which they cannot see, like charge and resistance."* P3 used *"demonstrations and hands-on activities to scaffold conceptual understanding and pracs where learners manipulate variables to understand concepts."* P4 implemented project-based learning, allowing *"learners to apply what they have learnt on electricity to solve problems in their community."*

According to [37] demonstrations bridge theoretical knowledge and observable phenomena, helping visualise invisible electrical processes. Hands-on activities enable learners to observe phenomena, develop science process skills, and validate theoretical concepts through empirical investigation. Singh-Pillay [38] and [39] note that project-based learning enhances technological literacy and scientific reasoning skills, aligning with constructivist learning theories emphasising active engagement [40, 41].

Digital Technology

Two of the six participants use technology in teaching the topic of electricity, as reflected in the comments below:

*"Simulations are great tools when you have non-functional equipment or no equipment for pracs -- they are good as learners can manipulate the resistor to test the bulb's brightness, and they are safe." (Interview, **P1**)*
"I use YouTube videos to teach some aspects on electricity – I found that it is a great way to capture the interest and participation of learners during the lesson, and it is interactive." (Interview, P4)

Using simulations and YouTube videos helps learners visualise abstract electrical concepts, complementing hands-on activities. By providing students with dynamic visual content, providing practical context for abstract ideas, and facilitating interactive and collaborative learning, YouTube videos and other digital media have revolutionized science education. By offering visual and interactive learning experiences, multimedia and interactive technologies greatly enhance students' comprehension of abstract electrical ideas [36]. Chen et al. [32] found that integrating multimedia into science education can enhance conceptual understanding by

40%, particularly in subjects that require complex spatial and functional reasoning like electricity.

P4 utilises PhET simulations to stage demonstrations, helping learners grasp concepts more effectively. These concepts include the flow of current and the distinction between voltage and electric current. Incorporating PhET interactive simulations has proved to be a powerful pedagogical tool. They are safe and provide a risk-free setting for investigating electrical concepts allowing students to interactively change factors like resistance, voltage, and current in real time, abstract ideas become more concrete and understandable.

Additionally, simulations help overcome equipment limitations often faced in resource-constrained educational settings. Singh-Pillay [42] emphasises that simulation-based learning increases student engagement compared to traditional lecture methods. The ability to experiment virtually allows learners to develop a deeper understanding of electrical principles through active exploration.

Overall, the teachers displayed a range of PCK, leveraging various instructional strategies to effectively teach the topic of electricity. This demonstrates a solid understanding of electrical to select and implement the most appropriate teaching methods.

Impact of pedagogy

Promotes Conceptual Learning and Collaboration

Effective electricity teaching has evolved from traditional equation-driven methods to student-centred approaches that promote conceptual understanding. Participants identified key pedagogical strategies, including discussion, jigsaw, think-pair-share, practical demonstrations, experiments, and project-based learning, essential for applying circuit laws to analyze electrical systems.

Classroom observations revealed innovative teaching practices. P1 transformed learning by presenting electricity as a narrative of human experience, guiding students to explore electrical mysteries through inquiry-based learning. Students traced electron movement like detectives, experiencing Ohm's law through conceptual mapping rather than memorization. P3 emphasized demonstrations and hands-on activities, using torches to explore connections while addressing student misconceptions through open discussions.

Research supports these pedagogical approaches. Edwards and Kumar [43] demonstrate that dialogic teaching enables students to articulate understanding, challenge misconceptions, and develop critical thinking skills through collaborative knowledge frameworks. The jigsaw method creates student "experts" who teach peers specific concepts. Vives et al [44] found that this approach fosters interdependence, enhances peer learning, and increases engagement with complex circuit theory.

Think-pair-share methods significantly impact learning outcomes. Chen and Wong's [45] meta-analysis revealed that this strategy reduces learning anxiety, promotes diverse perspectives, supports introverted students, and enhances conceptual retention by approximately 40%.

Practical demonstrations bridge theoretical knowledge with the application, making abstract electrical principles observable. Rodriguez et al. [46] showed that hands-on demonstrations reduce cognitive distance between theory and practice, improve spatial understanding, boost motivation, and provide contextual learning experiences.

These modern pedagogical approaches align with CAPS policy objectives [1] emphasizing the interaction between values, attitudes, technology, society, and the environment. Contemporary electricity teaching transcends circuits and equations, involving clear communication, concept clarification, and active engagement where learners articulate thinking, question ideas, and appreciate multiple viewpoints.

Promote Minds-on, Hands-on and Creativity Skills

Building on conceptual learning approaches, various pedagogical methods directly influence the development of minds-on, hands-on, and creativity skills. The curriculum emphasizes scientific, pedagogical methods, requiring teachers to guide students through hands-on experiences, mind-on engagement, and process skills development [1].

Teachers employ diverse strategies to promote these skills. P1 utilizes simulations, while P2 and P3 implement demonstrations, hands-on activities, projects, discussions, jigsaws, and think-pair-share strategies. P2 designed practical tasks focusing on the effect of series-connected cells on bulb brightness, developing learners' observation, comparing, measuring, hypothesizing, investigating, and recording skills. During lessons, students worked in groups using voltmeters, cells, LED bulbs, and conducting wires to explore electrical concepts through scientific processes.

P3 emphasized problem-solving through paired work: "During my lesson (practical lessons), my learners are forced to solve problems given to them while working in pairs. That improves their problem-solving skills and stimulates creativity." P1 leveraged technology, incorporating PhET simulations: "I give learners activities about electricity that will allow them to use PhET simulations... it greatly fosters creativity in learners."

Research supports these pedagogical approaches. Thompson and Singh [36] demonstrate that experimental approaches develop scientific inquiry skills, encourage hypothesis testing, provide real-world problem-solving experiences, and increase conceptual understanding through active exploration. Kim et al. [15] found that project-based learning fosters holistic understanding, encourages interdisciplinary thinking, prepares students for real-world engineering challenges, and promotes creativity in electrical system design.

These methods emphasize that learning is an active process in which students build knowledge through experiences and social interactions, which is consistent with constructivist learning theories [40, 41]. By breaking down difficult electrical ideas, establishing cognitive links between theory and practice, and correcting misconceptions with focused interventions, teachers exhibit in-depth subject matter expertise.

Through learner-centered tactics and inquiry-based learning, these transformative pedagogical approaches offer a paradigm change from passive knowledge transmission to active, collaborative learning experiences. They go beyond rote memory toward conceptual understanding.

6. CONCLUSION

A comparison of research data reveals a clear nexus in teachers' pedagogical practices when teaching electricity in Natural Sciences (NS) and Technology at the Grade 9 level. This connection manifests through multiple teaching strategies, including chalk-and-talk, discussions, demonstrations, hands-on activities, projects, and digital technologies such as simulations and YouTube videos.

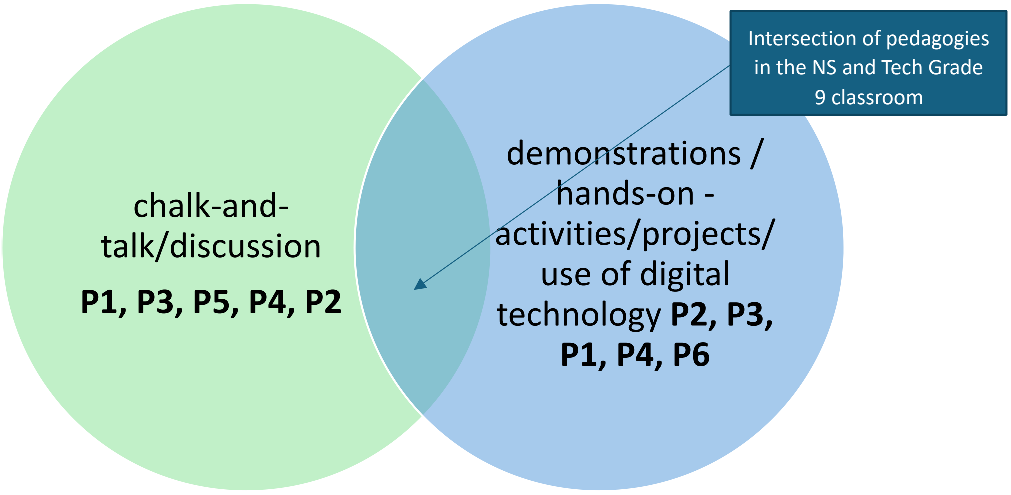

Figure1: Pedagogical nexus

The nexus can be understood through the Topic-Specific Pedagogical Content Knowledge (TSPCK) framework [28]. Teachers exhibit advanced TSPCK by transforming complex electrical concepts into accessible learning experiences, demonstrating Mavhunga's[28] definition of TSPCK as the capacity to convert subject-matter knowledge into pedagogically sound forms.

This transformation occurs across three key TSPCK components:

Student Prior Knowledge

Teachers actively address learners' existing understandings and misconceptions through various pedagogical strategies. P3's torch demonstrations exemplify how hands-on experiences link prior knowledge with new concepts.

Curricular Saliency

Teachers demonstrate strategic decision-making through diverse teaching methods, employing demonstrations, hands-on activities, discussions, and digital technologies appropriate for Grade 9 instruction.

Teaching Challenges

Teachers address inherent difficulties in electrical concepts through structured learning experiences, using collaborative strategies like jigsaw and think-pair-share methods. Chen and Wong [45] show that these methods increase conceptual retention by 40%. The pedagogical nexus illustrates how TSPCK components interact during teaching [47]. Teachers integrate strategies thoughtfully rather than using them in isolation, creating comprehensive learning experiences. This approach reflects [48] assertion that PCK value is best understood within specific topic contexts. The shift from traditional methods to active exploration demonstrates sophisticated TSPCK, where teachers facilitate learning rather than merely provide information [49]. Teachers create cognitive bridges between theory and practice through diverse pedagogical strategies, fostering environments where students engage in meaningful scientific investigation and problem-solving.

7. RECOMMENDATIONS

Based on the findings about the pedagogical nexus in teaching electricity at Grade 9 level, here are key recommendations:

Develop Integrated Pedagogical Approaches

Teachers should consciously combine multiple teaching strategies rather than using them in isolation. The research shows that integrating chalk-and-talk, demonstrations, hands-on activities, and digital technologies creates more comprehensive learning experiences.

Strengthen TSPCK Development

Focus on developing all three components of Topic-Specific PCK - understanding student prior knowledge, curricular saliency, and teaching challenges. This requires ongoing professional development, specifically targeting electricity concepts and common student misconceptions.

Implement Collaborative Learning Strategies

Given the 40% increase in conceptual retention from methods like jigsaw and think-pair-share (Chen & Wong, 2024), teachers should prioritize these collaborative approaches when teaching complex electrical concepts.

Design Topic-Specific Training

Create professional development programs focused on electricity instruction that help teachers transform theoretical TSPCK knowledge into practical classroom strategies.

Promote Reflective Practice

Encourage teachers to reflect on how their pedagogical choices address student misconceptions and support conceptual understanding of electricity topics.

Support Pedagogical Flexibility

Curricula ought to be designed in a manner that permit teachers to use different teaching methods as well as provide guidance on when and how to integrate different pedagogical approaches .

Include Misconception Resources

Provide teachers with resources identifying common student misconceptions about electricity and evidence-based strategies to address them.

Longitudinal Studies

Investigate the long-term impact of integrated pedagogical approaches on student understanding and retention of electrical concepts.

Cross-Curricular Connections

Explore how the pedagogical nexus between NS and Technology can be strengthened to enhance student learning outcomes in both subjects.

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