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The role of practical activities in teaching mechanical systems and control

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ABSTRACT

This study examined the role of practical activities in teaching Mechanical Systems and Control in Grade 8 Technology classrooms. Pedagogical practices play a vital role in facilitating learners' understanding of abstract mechanical concepts such as levers, pulleys and gears, particularly within under-resourced schools in South Africa. The study adopted a qualitative exploratory case study design and was conducted in the Madibeng Sub-District of the North West Province. Seven Grade 8 Technology educators were selected using expert purposive sampling. Data were collected through semi-structured interviews and open-ended questionnaires to explore educators' pedagogical practices, use of practical activities and perceived learner outcomes. The data were analysed using thematic analysis, following a systematic coding and categorisation process to identify key patterns and themes. The findings indicate that practical activities enhance learner participation, improve conceptual understanding and support the development of problem-solving skills by making abstract mechanical concepts more tangible and relatable. However, the findings also reveal challenges related to limited resources, time constraints and variations in educators' pedagogical content knowledge, which affect the effective implementation of practical work. Trustworthiness was ensured through data triangulation and participant checking. The study is limited by its small sample size and focus on a single sub-district, which restricts generalisability. Despite these limitations, the study highlights important implications for teacher support, resource provision and pedagogical improvement in Technology education.

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Introduction

Teaching Mechanical Systems and Control in Grade 8 Technology education in South Africa continues to present significant challenges, particularly in relation to the effective implementation of practical activities in resource-constrained school environments. Although practical work is widely recognised as central to developing learners' conceptual understanding and problem-solving abilities, many classrooms remain dominated by textbook-based and teacher-centered instructional approaches (Mokone & Hlalele, 2019). International studies similarly report that an overreliance on theoretical instruction limits learners' engagement with mechanical concepts and reduces opportunities for meaningful application (de Vries, 2018; Rasinen et al., 2020). Consequently, abstract concepts such as gears, pulleys and linkages are often taught in ways that lead to superficial understanding (Mhlolo & Umalusi, 2020).

Research in technology and engineering education consistently demonstrates that hands-on activities enable learners to connect theoretical knowledge with real-world mechanical applications (Kolodner et al., 2003; Merrill, 2013). However, the implementation of practical activities is highly dependent on contextual factors such as access to tools, materials, time and workshop facilities. In low-resource settings, educators are frequently required to improvise or limit practical work, which affects both the quality and frequency of learner engagement (McCormick & Murphy, 2021). These challenges are compounded by variations in educators' pedagogical content knowledge (PCK), which influence how mechanical concepts are represented, adapted and scaffolded for learners (Shulman, 1987; Kgosi, Makgato & Skosana, 2023).

While international literature has explored practical learning in STEM and technology education broadly, there is limited empirical research that examines how practical activities are enacted within specific curriculum strands such as Mechanical Systems and Control at lower secondary level, particularly in under-resourced contexts (Williams, 2017; Rasinen et al., 2020). In the South African context, existing studies tend to emphasise curriculum policy or learner outcomes without sufficiently interrogating educators' classroom practices and pedagogical decision-making under material constraints (Sithole & Moyo, 2023). This gap is especially evident in rural and semi-rural districts such as Madibeng, where resource disparities remain pronounced.

The novelty of this study lies in its focused exploration of how Grade 8 Technology educators implement practical activities when teaching Mechanical Systems and Control under conditions of limited resources. By foregrounding educators' pedagogical practices and contextual challenges, the study contributes context-specific insights that extend international debates on practical learning and PCK into under-researched South African settings. The findings aim to inform teachers of professional development, curriculum support and policy initiatives aimed at strengthening practical teaching in Technology education.

Recent research reveals a strong correlation between practical learning and increased learner outcomes in technology education. Also, Kheswa (2019) discovered that project-based learning enhanced student motivation in rural schools. Sibeko (2020) demonstrated that learners who worked on collaborative mechanical constructs improved their communication and teamwork abilities, as well as their content understanding. According to Ledwaba (2023), the successful implementation of practical activities requires both teacher confidence and institutional support.

Bridging theory and practice entails linking mechanical concepts with real-world examples and experiences (Shulman, 2023). In the technology field, it allows learners to bridge learning and develop reflective practice. According to Laurillard (2022), when educators utilize this method, it promotes learning by aligning instructional approaches with class objectives and learners' requirements.

Initial findings from this study reveal that practical activities improve learner understanding of key mechanical systems. In the same footing, Morake (2022) asset that after constructing a gear system, learners could accurately describe force transfer. However, Ramotshela (2021) noted that learners participating in model-building activities showed greater curiosity and attention during theory lessons. Mokgosi (2023) argued that such engagements also foster long-term retention of technological concepts.

The study concludes that hands-on learning must be embedded in the pedagogy of mechanical systems and control to improve learner outcomes. Majola (2020) advocates for policy reforms that provide teachers with the resources needed for sustained practical instruction. Nkuna (2022) suggests that teacher training should focus on equipping educators with strategies to manage practical activities effectively. Booi (2024) calls for further research into scalable, context-sensitive models that support Technology teaching across diverse school environments.

Method

The study employed a qualitative, exploratory case study design to investigate how Grade 8 Technology educators implement practical activities in teaching Mechanical Systems and Control. Seven educators from the Tshwane West District in South Africa were purposively selected based on their active engagement with the curriculum and reported use of practical activities in the classroom (Patton, 2002). Purposive sampling ensured that participants had relevant experience and insight into the challenges and strategies associated with teaching mechanical concepts under varying resource conditions. Ethical clearance and permission from the relevant educational authorities were obtained prior to data collection, and all participants provided informed consent.

Data were collected over a six-week period through semi-structured interviews and open-ended questionnaires. The interviews included broad, open-ended questions designed to elicit detailed descriptions of pedagogical practices, while the questionnaires provided participants the opportunity to reflect in writing on classroom constraints, resource availability and learner engagement. Interviews were conducted in person, audio-recorded with consent and transcribed verbatim. Questionnaires were returned within one week, supplementing the interviews and enabling triangulation of data sources.

The study employed thematic analysis following the six-phase process outlined by Braun and Clarke (2006), which included familiarisation with the data, generation of initial codes, identification of preliminary themes, reviewing and refining themes, defining and naming final themes and producing a narrative report supported by illustrative quotations. NVivo 12 software was used to organise and manage data systematically, ensuring consistency and transparency in coding. Trustworthiness was established through multiple strategies. Credibility was enhanced through triangulation of interviews and questionnaires; participant checking was conducted to allow participants to verify the accuracy of preliminary interpretations.

Transferability was addressed by providing detailed contextual descriptions of participants, classrooms and resource constraints. Dependability and confirmability were ensured through a comprehensive audit trail documenting research decisions, coding procedures and analytical reflections. Additional measures included iterative cross-checking of codes among the research team to reduce bias and strengthen interpretive accuracy.

The methodological approach enabled the researcher to capture nuanced patterns in educators' use of practical activities and to explore how contextual factors influenced pedagogical choices. By combining interviews and reflective questionnaires, the study was able to identify both observable practices and the underlying reasoning guiding educators' decisions.

This approach provided a holistic understanding of the implementation of hands-on learning in Mechanical Systems and Control, highlighting both effective strategies and barriers related to limited resources, time constraints, and variations in pedagogical content knowledge. Overall, the design and data analysis process ensured that the findings were grounded in participants' authentic experiences, providing credible and context-specific insights into the challenges and opportunities of teaching Technology in Grade 8 classrooms.

Results and Discussions

The study found that practical activities significantly enhanced learners' comprehension of mechanical systems and control also increased their engagement in class. Educators consistently reported that when learners manipulated materials and constructed working models, abstract concepts such as force transmission, pulleys and gears became more tangible. One teacher explained, "After building a model of a pulley system, learners could describe exactly how force moves and changes direction—they understood it far better than from the textbook alone." Another noted, "Learners were more active and asked more questions after the hands-on demonstration." These findings align with experiential learning theory, which emphasizes that knowledge is constructed through active engagement and reflection on experiences (Kolb, 1984; Merrill, 2013). The results also reflect the principles of pedagogical content knowledge (Shulman, 1987), as teachers' ability to contextualize and scaffold practical tasks was key to learner understanding.

Despite these positive outcomes, the implementation of practical activities was uneven. Constraints such as overcrowded classrooms, limited teaching materials and insufficient professional development meant that many educators relied primarily on theoretical instruction or improvised with local resources. As one participant admitted, "I often have to use makeshift materials, which limits what learners can do and how deeply they explore the concepts." This observation supports international studies highlighting that resource limitations can hinder effective STEM instruction (Beetham et al., 2019; McCormick & Murphy, 2021). The findings underscore that while practical activities are essential, their success depends on systemic support, adequate resources and teacher confidence in integrating hands-on methods.

Collaborative learning emerged as an important mediator of practical activity outcomes. Educators observed that learners working in pairs or small groups during hands-on tasks demonstrated improved problem-solving and communication skills. One teacher stated, "When learners build models together, they discuss strategies, correct each other, and often find solutions faster than individually." This echoes findings from Sibeko (2020) and international literature emphasizing the benefits of cooperative learning for enhancing conceptual understanding and cognitive engagement (Johnson et al., 2014; Hmelo-Silver et al., 2007). It suggests that practical activities not only facilitate content mastery but also foster critical social and cognitive skills.

The results also indicate that novelty and teacher enthusiasm may contribute to increased learner engagement. Engaging with physical materials in a traditionally theory-based classroom likely provides intrinsic motivation, while teachers' energy and scaffolding strategies further support active learning. This supports constructivist perspectives, which highlight the role of interaction, motivation and scaffolding in meaningful learning (Vygotsky, 1978; Laurillard, 2022). In addition, repeated exposure to model-building activities enhanced problem-solving skills, reflecting international evidence that iterative hands-on practice strengthens learners' ability to analyze, design, and troubleshoot mechanical systems (Kolodner et al., 2003; Molenaar et al., 2019).

Figure 1. Educator A's practical demonstration

Educator A had an advantage of being able to demonstrate to learners using machinery in the class. See Figure 1 above. Learners were able to use the machine to perform a practical following a lesson. The study also highlighted broader implications of practical activities for workforce readiness and skills development. By engaging learners in hands-on construction and experimentation, practical learning nurtures foundational engineering and technical skills that are essential in vocational and STEM-related pathways. This aligns with national and international priorities to prepare students for technology-driven economies (OECD, 2020; National Research Council, 2012). Practical activities thus serve not only educational but also socio-economic functions by bridging classroom learning with real-world applications.

However, the study had limitations that should inform interpretation. The small sample of seven educators from one district limits generalizability and self-reported data may introduce bias. While classroom observations were conducted to validate practices, expanding observation across multiple schools would strengthen evidence. Future research should include diverse socio-economic contexts, explore structured professional development interventions and investigate scalable, cost-effective models for hands-on instruction in resource-limited schools. Further international comparative studies could also illuminate how context, policy and pedagogy interact to support effective practical learning in technology education.

Conclusions

This study set out to examine how educators' reliance on experiential teaching approaches influences the development of learners' mechanical understanding, particularly in relation to pedagogical content knowledge (PCK) and content knowledge (CK). The findings indicate that while experience-based strategies such as scenarios, analogies, and worksheets increased learner engagement, they were often insufficient for fostering deep conceptual understanding of core mechanical principles. In line with international research, effective science learning requires the deliberate integration of conceptual explanations, disciplinary language, and structured feedback rather than trial-and-error learning alone (Hattie, 2012; Shulman, 1986). The persistent gap between learner participation and conceptual clarity highlights that motivation does not automatically translate into understanding. Therefore, the study confirms that the research purpose was met by demonstrating how inadequate reinforcement of mechanical concepts limits meaningful learning outcomes.

The findings have several practical implications for classroom practice and educational policy. Teachers should be supported to design lessons that intentionally link hands-on activities with explicit conceptual explanations, formative assessment, and scaffolding opportunities. Strategies such as concept checks, guided questioning, and structured reflection can help learners consolidate ideas like mechanical advantage, effort, and load (Black & Wiliam, 2009). From a policy perspective, professional development programmes should prioritize strengthening teachers' PCK in physical sciences, particularly in the use of scientific language and formative feedback. Curriculum planners should also ensure that annual teaching plans allow flexibility for concept reinforcement rather than prioritizing coverage alone, a recommendation echoed in international studies on curriculum coherence and teacher effectiveness (OECD, 2019; Darling-Hammond et al., 2017).

Despite these contributions, the study has certain limitations that should be acknowledged. The research was limited to a specific context and subject area, which may restrict the generalizability of the findings to other disciplines or educational settings. Additionally, the study focused primarily on classroom practices and did not measure long-term learner achievement outcomes. Future research could explore longitudinal effects of targeted PCK interventions or examine how digital tools and peer feedback support conceptual understanding in mechanics. Nonetheless, the study provides valuable insights into the necessity of aligning theory and practice through intentional pedagogy, offering evidence-based guidance for improving science teaching and learning both locally and internationally.

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