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Experiences by Novice Science Teachers with Teaching Rotation and Revolving: A Case Study of Primary Schools in South Africa, Gauteng Province

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Abstract

The scarcity of experienced science teachers in South Africa has led to the rapid recruitment of novice teachers, who often face challenges that impact their performance. This study investigates the specific difficulties these novice teachers encounter when teaching the concepts of rotation and revolution within the "Planet Earth and Beyond" strand of the Grade 6 Curriculum and Assessment Policy Statement (CAPS)concepts foundational to later science learning. Guided by the theories of Transformative Pedagogical Content Knowledge (TSPCK) and Social Constructivism, this qualitative research employed a case study design. A purposive sample of 15 novice science teachers participated in the study. Data were collected through semi-structured interviews and focus group workshops and analyzed using thematic analysis. The findings reveal that novice teachers struggle with a lack of practical pedagogical techniques and insufficient content knowledge to simplify these abstract astronomical concepts. A key insight was their difficulty in creating hands-on activities that effectively demonstrate the differences between rotation and revolution. Based on these findings, the study concludes that structured, sustained support is crucial. It specifically recommends the implementation of an 18-month internship program where novice teachers are mentored by experienced practitioners to acquire essential pedagogical skills. Furthermore, the research proposes the development of TSPCK policy for science

Keywords: keyword1; Novice Teacher; Rotation; Revolving

Introduction

The decreasing competency in science education within South African schools offers a significant difficulty, which is made worse by a downturn in the number of students enrolling in higher grades and their overall performance in those grades. Even if there has been an increase in the recruitment of new teachers, this tendency continues. Most of the time, novice science teachers, particularly those working in elementary schools, are confronted with severe pedagogical challenges and are forced to turn to didactic rather than experimental approaches. The TIMSS 2019 statistics suggest that there is a significant lack of achievement in the teaching of fundamental concepts such as the rotation and revolution of the Earth. This issue is acutely demonstrated in the teaching of these concepts. Considering this, the purpose of this study is to analyze the specific obstacles that novice teachers in the province of Gauteng have while attempting to teach these ideas to eighth grade students. It is crucial to identify these barriers to develop focused interventions to support novice educators, which will ultimately result in an improvement in the quality of instruction and the outcomes for students in the subject of science.

Difficulties in teaching rotation and revolving of planet Earth

Research indicates that teacher Content Knowledge (CK) and pedagogical content Knowledge (PCK) are predictors of minority student performance in understanding associated Science material as alluded by Reynolds & Park (2021). These findings align with an expanding

corpus of research connecting teacher subject-specific content knowledge (CK) and pedagogical content knowledge (PCK) to student accomplishment in those areas. These findings about teacher CK align with educational production function literature research. Fitzmaurice, Walsh, & Burke, (2021). assert that the assessment of teacher subject-specific expertise is closely linked to student learning and comprehension of science ideas.

Higher Education Institutions (HEI) have designed teacher education content for the intermediate and senior phases, including FET Alex & Trow (2023). The curriculum is designed to cater to learners based on their cognitive development and what their mind capacity can carry. This progression assists in curriculum development for learners of the correct age.

Graham, Fuentes, & Jimerson (2022) point out that teachers' understanding of science concepts significantly impacts students' learning of science. Most primary school teachers are not as effective in teaching Science as in other subjects, which means they experience difficulties. This dramatically impacts Science as a subject as it is viewed as problematic. Research by Gess-Newsome, Taylor, Carlson, Gardner, Wilson, & Stuhlsatz (2019). points out that four out of five teachers have difficulty with science content knowledge, significantly impacting learner performance. The above finding indicates the importance of teacher capacitation in content knowledge that will benefit learners.

The learning deficit evidence in science matric results yearly in South Africa should indicate that something is missing in class where teaching and learning happen. This does not start in higher grades but is carried over from the foundation of knowledge. Despite different strategies to improve learners' performance in matric results for science students, there is still no improvement, as indicated by DoE (2021) matric performance. The learning deficit evident in science matric results yearly in South Africa should indicate that something is missing in class where teaching and learning happen, and this does not start in higher grades but is carried over from the foundation of knowledge. Despite different strategies to improve learner performance in matric results for science students, there is still no improvement, as indicated by DBE (2021), in matric performance. The scarcity of sufficiently qualified Mathematics and Science educators continues to be a widespread problem in most areas of South Africa. Educational institutions in this area face the simultaneous task of recruiting and retaining subject instructors with limited abilities (Muremela et al., 2023).

Effective recruitment and retention of new teachers are paramount, especially in rural regions where schools struggle to attract and retain teachers to tackle ongoing shortages. Thus, many of these school administrators encounter limitations in achieving their school objectives since their schools lack sufficient instructors in scarce skills disciplines. Teacher turnover in Mathematics and Science education may be classified into two discrete categories: supply and demand dynamics Yang & Lim (2021). The first phenomenon, sometimes known as teacher attrition, refers to persons who choose to abandon their involvement in the instructional profession. The second classification, sometimes referred to as teacher migration, concerns those who move or shift to other teaching roles within various educational institutions. A strong agreement exists that inadequate performance in Natural Science and Technology (NST) relates to several problems, including ineffective teaching methodologies, substandard assessment techniques, insufficient resources for subject demonstration, and teachers' lack of topic understanding and pedagogical content knowledge (PCK) (Bantwini, 2017). Teachers' primary challenge in employing ineffective teaching approaches is their need for individualised teaching styles. They often employ pedagogical techniques that their teachers previously applied throughout their educational experiences.

Intervention strategies to ensure effective teaching of science subjects

Countries worldwide have implemented many tactics and programs to address the challenges faced by novice Science teachers, alleviating their frustrations (Ilgaz et al., 2019). A study on teachers' pedagogical subject knowledge and students' academic progress was done to examine this assertion (Jacob, John & Gwany, 2020). Theoretical analysis in the Journal of Global Research in Education and Social Science has demonstrated that teachers are not blameless. Teachers must be aware of how to enhance learners' science education, as noted by Thomas, Julie, Utley, Hong, Korkmaz, and Gwen Nugent (2020). Blended learning is a viable pedagogical approach; but more effective ways may emerge. The study will encourage educators to be inquisitive about alternative strategies that may enhance the teaching of rotation and revolution, so fostering confidence and improving student performance in all aspects.

A study conducted in Ethiopia has revealed that “teacher’s knowledge domain affects students’ achievement” (Ayele & Kind, 2017, p. 36). A teacher’s level of content knowledge has a direct effect on learner achievement. Kassa & Bogale (2020) points out that students who joined basic Science departments between the 2006/7 and 2008/9 academic years were low achievers in the Ethiopian University Entrance Examination. Zimbabwe indicated similar findings and asserted that teacher CK and PCK predicted minority student success in grasping the related science content (Chikwanha et al., 2019). These findings are consistent with a growing body of research linking teacher subject-specific CK and PCK to student achievement in those subjects. Based on the current situation, which includes the average performance in Physical Science for GET grades 10 to 12 and low enrolment trends by South African learners DoE(2020), it is apparent that the concern about the low status of Mathematics and Science education in the country is not justifiable DoE (2021). If this occurrence is not addressed, reflecting that few learners enrol for Physical Science from Grade 10 based on the perceived difficulty of this subject, South Africa will continuously depend on other countries for STEM subjects.

Therefore, in South Africa, Science education needs radical transformation from early grades to instil interest and unearth different skills in learners, and teachers are the groundbreakers in this regard. Moreover, mentoring novice teachers is often seen as an intervention approach. Fostering self-confidence in teaching is highly challenging within the teaching profession. Mhlaba (2019) effectively summarised this by asserting that the "absence of a well-organized mentorship approach has a profound impact on novice teachers, leading to a significant number of them abandoning the teaching profession" (Mhlaba, 2019, p. 18).

Language of learning and teaching (LOLT)

The language of learning and teaching (LOLT) in science serves as an intervention method. Kibirige and Mogofe (2021) assert that the language utilised in teaching and learning poses issues for Physical Science educators and affects students' performance. Research conducted by Lyon et al. (2016) demonstrates that for more than fifty years, professionals in science education have advocated for incorporating language literacy into physical science instruction. Howie, Combrinck, Roux, Tshele, Mokoena, and McLeod Palane (2017) reported on the Progress In Reading Literacy Study (PIRLS), which indicates that nearly 78% of Grade 4 students in South Africa do not meet global standards and consequently lack essential reading skills after the Grade 4 academic year, in contrast to only 4% of learners globally. South Africa placed last among the 50 participating countries in PIRLS 2016. South Africa's performance was equivalent to Egypt's, with no statistically significant difference. Consequently, learners must possess reading and writing skills to enhance inquiry-based learning (Maeve & Niamh, 2018; Meskill & Oliveira, 2019; Graham, 2020). To comprehend scientific concepts, the language of instruction must be integrated to facilitate learners' understanding of the topic. In science education, the integrity of

concepts and vocabulary must be maintained to prevent misconceptions. Precautions must be observed when instructing in science, as a topic is replete with specialised terminology; hence, educators must be proficient in content understanding.

Theoretical Frameworks

Topic-specific pedagogic content knowledge

To improve learners' comprehension within their local context, teachers were encouraged to transition from "knowing what to do" (knowledge that is evident in planning) to "doing what you know" (knowledge that is evident in classroom presentation) through the adoption of the theoretical construct of pedagogical content knowledge (PCK) specifically topic-specific pedagogical content knowledge (TSPCK) Mavhunga & van der Merwe (2020). It is asserted that a teacher's subject-matter pedagogical competence is contingent upon incorporating appropriate analogies, illustrations, examples, explanations, and concepts to improve the topic's accessibility for students. This content includes academic skills in the subject-specific curriculum, pedagogical proficiency in both general and specialized aspects of the field, and knowledge of the frameworks of the topic.

Social constructivism theory

To expand upon this, the Constructivist theory of Vygotsky (1978), which emphasises the co-construction of knowledge through interaction and the zone of proximal development, will be employed to comprehend the teaching methods of novice Science instructors and the challenges they may encounter when teaching rotation and revolving techniques. According to this theory, learning occurs through interactions within communities, peers, teachers and other mentors. According to Vygotsky (1978), knowledge is co-constructed, and individuals learn from one another in an active and engaging activity. This theory, therefore, includes the development of novice science teachers based on their interaction with the environment they teach and their association with peers and mentors. This association could help influence their development and practice within teaching. According to Shernoff, Sinha, Bressler, and Ginsburg (2017), interaction can assist research participants in talking about possible challenges, opportunities, or supports when designing or teaching new content.

As Vygotsky (1978, p. 86) articulated, the zone of proximal development ‘refers to the” gap between the actual developmental level, as assessed through independent problem-solving, and the potential developmental level, as evaluated through problem-solving with adult assistance or collaboration with more knowledgeable individuals”. For this study, novice science teachers had to learn that they should accept and complete challenging tasks outside their abilities, eventually promoting cognitive growth. Teaching the concepts of rotation and revolving of planet Earth would require them to understand how the two concepts are understood to eliminate misconceptions. In this study, it is predicted that as novice teachers interact, analyse, demonstrate, engage and reflect on teaching about rotation and revolving, they may develop an understanding, meaning, or interpretation of knowledge they acquired from the interaction with other teacher educators and researchers. Therefore, the constructivist approach and TSPCK may significantly influence a teacher's methodology in science education.

Method

The study employed the qualitative, interpretative epistemology approach. Creswell (2018) defines the qualitative approach as an investigation of a phenomenon using the collective experiences and attitudes of the participants. This methodology acquires knowledge from the given environment's values, views, viewpoints, and social settings. Furthermore, the qualitative approach ensures that deep insights and perspectives can be gathered through direct

observation, interviews, questionnaires, focus groups, participant observation, natural setting recordings, documents, and artefacts.

Summary of the interview instrument

The researcher conducted post-intervention interviews, using a voice recorder with participants' permission. The questions gathered insights on early-career mentorship experiences from new teachers, mentors, and South African policymakers regarding induction policies.

Target populations and sampling

The target population for this study were 15 grade 6 novice natural Science teachers in the Gauteng Department of Education, Tshwane South District. The study employs a non-probability sampling methodology using purposive sampling since this method facilitates the inclusion of people possessing extensive knowledge of the subject topic (Creswell, 2018).

From the population of five primary schools in Tshwane South district in GDE, 15 teachers were selected using purposive samples from each school. Each school was represented by three teachers in the intermediate phase and one in the senior phase, novice Science teachers. Ethical clearance was obtained to obtain permission. This technique is proper when a researcher knows the target population's characteristics and then pursues specific individuals with those characteristics to include in the sample Creswell, (2018).

Inclusion and exclusion criteria

The research was conducted only in English and focused on beginner novices of Natural Science to sixth-grade students, omitting experienced teachers in this field. The study concentrated on the rotation and revolution of Earth. It was conducted in the Tshwane South District within the Gauteng region of South Africa. The study established criteria to evaluate and choose relevant studies while excluding those not fulfilling essential standards.

- The project specifically targeted novice primary school teachers with fewer than 5 years of experience teaching Natural Science to Grade 6 students in primary education.
- The study focused on information from natural science connected to planet Earth's rotation and revolution.
- The study did not intentionally include other topics in the Natural Science subject for Grade 6 and other grades in the schooling were excluded in this study; the remaining eight provinces in South Africa were also excluded in this study

Data collection

The researcher exercises direct control and supervision over the data-collecting process. The data was gathered using interviews conducted using questionnaires. The Focus group interviews were used as the primary data collection method in the study. Panter (2018) explains a focus group interview as an exercise involving a small number of demographically placed participants included in a study. The researcher conducts the interview session after the intervention or research activities. However, after asking permission from the participants, a voice recorder was used to record the interview session for accuracy; the researcher will handle this for safekeeping. The participants were assured of confidentiality and provided with information on the study's objective and advantages.

Data analysis

A theme analysis was used to analyse the data in this study. Hence, the data were presented schematically, utilising themes and codes to simplify the inference of their importance. These themes directed the researcher in determining how to offer a comprehensive account of the data. Campbell, Goodman-Williams, Feeney & Fehler-Cabral (2020). to enhance the researcher's comprehension of instructors' challenges in instructing Grade 6 students on rotation and

revolving ideas. The study question reflected the themes identified from the survey participants' data. The findings reported in this study effectively address the primary objective of the research.

Results and Discussion

The study identified four primary challenges faced by novice Grade 6 teachers in Gauteng when teaching the Earth's rotation and revolution.

- Deficits in Pedagogical Content Knowledge (PCK): Data revealed a critical lack of topic-specific content knowledge (CK) and PCK. Most participants (70%) had not engaged in professional development, citing financial constraints and a lack of confidence. Many avoided in-depth classroom discussion, relying solely on textbooks. Time constraints in the curriculum further exacerbated these difficulties.
- Difficulty with Specific Concepts: Teachers expressed being overwhelmed by the subject matter. A significant finding was the persistence of deep-seated alternative conceptions (e.g., "the sun rises") among teachers themselves, which conflicted with the scientific models they were required to teach.
- Limited and Inequitable Use of ICT: While teachers acknowledged ICT's potential for making concepts concrete, access was a major barrier. Educators in rural schools reported a complete lack of technological infrastructure. Even in schools with resources (e.g., a science lab), these were often underutilised. Teachers using personal devices received no institutional support.
- Language and Misconceptions: The Language of Learning and Teaching (LOLT), predominantly English, posed a significant hurdle. Teachers struggled with scientific terminology, and learners limited English proficiency hindered concept understanding. This intersected with societal misconceptions, which teachers felt ill-equipped to correct, leading to frustration and the perpetuation of errors.

Interpretation

These findings collectively indicate that novice science teachers operate within a complex system of constraints that severely impact pedagogical efficacy.

- The deficits in CK and PCK are not merely personal shortcomings but are systemic, linked to inadequate training and support. This aligns with literature confirming a strong correlation between teacher content knowledge and student achievement. The persistence of teachers' own misconceptions underscores how pre-existing societal beliefs actively dilute scientific instruction, suggesting that teacher education must explicitly address conceptual change.
- The inequitable access to ICT resources reflects and reinforces broader socio-economic disparities in the education system. It interprets the lack of devices not just as a resource issue, but as a critical barrier to achieving curricular objectives that demand concrete demonstration.
- The language challenge is interpreted as a fundamental gatekeeper to scientific literacy. The need for teachers to code-switch highlights a gap between policy (English as LOLT) and classroom reality. This, combined with entrenched misconceptions, creates a compounded barrier where language impedes the correction of false beliefs.

Ultimately, the data interprets the novice teacher's challenge as a multifaceted crisis of support spanning knowledge, resources, and language which results in diminished teacher confidence and, consequently, compromised learner understanding of foundational scientific concepts

Recommendations

Recommendations target the Department of Basic Education (DoE) and the Department of Higher Education Institutions (DHETI) for teacher training and to improve the development of training materials. Again, to provincial education departments, district offices, school management teams, departmental heads, and natural sciences instructors to adopt diverse strategies that bolster introductory science education in schools and improve the instruction and assessment of science. The analysis examines preventative ways to mitigate present behaviours that obstruct effective teaching on the rotation and revolution of planet Earth.

Technology pedagogy content knowledge approach (TPACK)

Significant technological integration necessitates more than just computer usage. Therefore, today's novice teachers must cultivate not just their understanding of subject matter and teaching methods but also their capacity to effectively use technology in these essential areas of teaching proficiency. The TPACK framework, as sited by Mishra, Gorakhnath, Lata, Rani & Chopra, (2022) is used to assist pre-service teachers in understanding how to integrate technology into their teaching practices. It is, therefore, of great importance that novice teachers incorporate it into their teaching as they join the profession or are given a new subject; Science is the one that needs more of it.

Enhancing Topic-specific pedagogy content knowledge (TSPCK)

The study suggests the following recommendations to the Department of Basic Education: DBE develops policies and guidelines on school structure and composition of School Management Teams (SMT) and their functionality according to Personnel Administration Management (PAM). The Departmental head (DH) of Natural science in a school is the line manager of a teacher school; he/she is responsible for the orientation and inducting of teachers who join the subject they manage. This includes intensive training on the subject policies, relevant documents, and other procedures. The assumption when new teachers join the profession is that they are fresh from the teacher training institution; therefore, they know the content knowledge. It is correct to assume that teacher educators see the content of the subjects they are training to teach. However, real classroom experience is different from teaching practice. It could be challenging for novice teachers to manage a subject and follow the Annual Teaching Plan (ATP). This document is paced and must be strictly followed as it is a national policy, and novice teachers might need help managing time as they are expected to do five-cycle reporting.

Designated training Institutions for Science teachers

The study recommends that the government and schools initiate training institutions designed only for science teachers. The designated training institutions should have special entry requirements in physical Science performance in Grade 12 to keep the Science standard high. Furthermore, the curriculum must address all concepts as they are on the set curriculum.

Science and Technology sectors

The science and technology sectors in South Africa need to adopt schools that work together to raise awareness of what is happening in the world of work and innovation. The South Africa National Space Agency (SANSA) mission is to Stimulate interest in science and develop human capacity in space science and technologies in South Africa. It also aims to create an environment that promotes industrial development and nurtures space-related partnerships to enhance South Africa's standing in the community of nations. The mission could be strengthened by visible collaboration with primary schools, which assists teacher-trainers and novice teachers explain the objects in the solar system. This collaboration must assist in strengthening primary science education.

Internship programmes for qualified science teachers

Internship programmes might assist in areas such as content knowledge, handling of apparatus, and technology pedagogic content knowledge (TPACK). The programme could be designed so that qualified science teachers are allowed to practice teaching science topics alongside a mentor or an experienced teacher. The programme could run for 18 months and offer a stipend and a certificate of competence after completion. This is not overruling the 4-year educator training course but bringing a prospect teacher into the real world of work.

Science misconception and myth corrective public dialogues

Media is a highly effective weapon that any country may utilize to teach, learn, unlearn, and influence people. As a country, we hold many beliefs regarding creation and the presence of supernatural powers. This offers us a sense of belonging and helps us strengthen our faith. Generally, the Sun rises in the east and sets in the west. We all use This daily language implicitly, from traditionalists to scientists. What does science say about the movement of such bodies in our solar system?

Subject consent statement

Informed consent was obtained from all participants involved in this study. The participants were informed about the purpose and objectives of the research, assured of the confidentiality of their information, and asked for permission before the interview sessions were audio-recorded. Participation in the study was voluntary.

Clinical trial registration

This study is a qualitative case study in science education and does not involve a clinical trial. Therefore, clinical trial registration is not required.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The author declares that the generative artificial intelligence (AI) tool ChatGPT and Grammarly were used exclusively for language editing and/or grammatical improvement. The use of AI did not influence the scientific content, study design, data analysis, data interpretation, results, or conclusions of the manuscript. Full responsibility for the content remains with the author.

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper

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