Teaching of Mitosis in South African classrooms: Instructional strategies and challenges[1]

Susan Nyirenda, ORCID: 0009-0000-1335-3057, Department of Science, Mathematics and Technology Education, University of Pretoria, South Africa

Johannes Jozua Rian de Villiers, ORCID: 0000-0002-6227-5558, Department of Science, Mathematics and Technology Education, University of Pretoria, South

ABSTRACT

Mitosis is a fundamental biological process that underpins various concepts in Life Sciences (Biology). Consequently, fostering a strong scientific foundation is widely recognised as essential for learners to develop logical reasoning skills. The current study examines the instructional strategies used and challenges faced by teachers in teaching mitosis topics in the FET (Further Education and Training) phase in South African Grade 10 Life Sciences (Biology) classrooms. Eight teachers in one of the circuits of the Gert Sibande District, Mpumalanga Province, participated. An interpretive approach was adopted, with the conceptual framework of pedagogical content knowledge guiding the research. Interview data underwent content analysis, while thematic analysis was used for the lesson observation data. The study identified a deficiency in creative, topic-specific instructional strategies, particularly those incorporating technology. Additionally, the study revealed that teachers struggled with mitosis-related content and terminology, demonstrating limited pedagogical content knowledge. The subject advisers are encouraged to conduct workshops for teachers on challenging Life Sciences (Biology) content as well as training teachers to use of technology in teaching Life Sciences (Biology) topics such as mitosis.

Keywords: Life Sciences (Biology), instructional strategies, instructional materials, mitosis, teaching challenges

INTRODUCTION

In the current decade, there are notable shifts and advancements in Life Sciences (Biology) instructional strategies (Moyo, 2019). Traditional instructional strategies, which demonstrated limited learner engagement, are giving way to more interactive and learner-centred instructional strategies (Moyo, 2019). Increased interactive and learner-centred instructional strategies .aim to enhance learners' engagement (Moyo, 2019). Reviewed literature shows that learner-centred instructional strategies such as use of simulations by means of documents, virtual reality and role play have demonstrated a substantial positive impact on education (Chernikova et al., 2020; Mystakidis et al., 2022). In addition, research has demonstrated

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that learners generally hold a favourable outlook on active learning strategies (Moyo, 2019; Van Horne & Rakedzon, 2024). Due to advancements in teaching aids and learning goals, there has been a noteworthy transformation in instructional strategies (Elkhidir, 2020). Numerous instructional strategies have emerged, seeking to achieve the objectives of the learning process by transitioning from teacher-centred to learner-centred instructional strategies (Elkhidir, 2020).

Questions about meiosis and genetics necessitate a prior understanding of mitosis concepts (Stern et al., 2020). The questions based on mitosis topic resulted in learners achieving the lowest scores, averaging 35% compared to other Grade 12 topics assessed in the November 2022 final examination. Moreover, research indicates that merely 39.5% of Grade 12 Life Sciences (Biology) candidates scored above 40% (Department of Basic Education [DBE], 2023). This issue has been extensively studied in the field of education, with a substantial amount of literature underscoring the challenges faced by secondary (high) school learners in understanding mitosis and meiosis (Machová & Ehler, 2023; Sachyani et al., 2023). Some suggested reasons for these challenges include the notion that the instructional materials and instructional strategies used by Life Sciences (Biology) teachers may not adequately tackle the difficulties faced by learners (Luwoye et al., 2021; Yaki et al., 2020). Against this background, the current study aims to explore how teachers teach mitosis topics, what instructional strategies they implement and the content they utilise. Additionally, the current study sought to identify the challenges faced by Life Sciences (Biology) teachers while teaching mitosis topics.

Mitosis is the process of cell division where one cell produces two genetically identical daughter cells, leading to cell duplication and reproduction. Mitosis is a type of cell division that occurs in somatic cells and facilitates the asexual reproduction of unicellular eukaryotic organisms (McIntosh, 2016). Furthermore, mitosis allows for growth and repair of worn out tissues in the body.

Reviewed literature reveals that challenges in teaching mitosis fall into several categories: planning (or lack thereof), content mastery, pedagogical strategy implementation, teaching competencies, and access to instructional materials (Yang et al., 2019; Gaigher & Nxumalo-Dlamini, 2019; Kadarisma et al., 2019; Osman et al., 2017; Rollnick & Mavhunga, 2017; Dumanjog, 2019; Etobro & Banjoko, 2017; Widyawardana et al., 2021; Yurnetti et al., 2021). Delivery time—when mitosis is taught—also affects instructional effectiveness (Awang-Kanak et al., 2016; Osman et al., 2017). Teachers often struggle with limited teaching time, which hinders the use of audio-visual aids (Sachyani et al., 2023). Literature reviewed revealed that some teachers deliberately avoid power-dependent instructional materials despite available electricity (Suraj et al., 2021). Additionally, teachers lack sufficient training in operating mechanical teaching devices coupled with and a lack of instructional assistants that ultimately negatively impact concept delivery, reducing learner achievement (Suraj et al., 2021).

Literature on mitosis teaching that was reviewed indicated that a lack of instructional materials and laboratory activities further hinders mitosis instruction (Etobro & Banjoko, 2017; Osman et al., 2017). Limited instruction time restricts critical thinking development, while last-minute teaching before exams exacerbates difficulties (Osman et al., 2017). In South Africa, load-shedding disrupts teaching, preventing teachers from using electrical teaching aids. Research

highlights the importance of practical experiments and visual aids in knowledge acquisition, emphasizing the negative impact of power shortages on effective instruction (Matsheta & Sefoka, 2023).

The primary research question that was addressed by the current study reads as follows:

How is the topic of mitosis taught in Grade 10 Life Sciences (Biology) in Mpumalanga, South Africa?

The secondary research questions (SRQs) that are addressed are:

SRQ1 What topic-specific instructional strategies and content do the teachers use to teach mitosis?

SRQ2 What challenges do the teachers face when teaching mitosis?

LITERATURE REVIEW

The reviewed literature indicates that digital tools such as the internet, perception systems, video recording, image recognition, and platform acquisition, enable the collection of diverse, multi-source, and multimodal big data related to learners' learning processes. These digital tools mentioned above can help learners learn in a personalised way that is just right for them (Cheung et al., 2021). Cheung et al. (2021) state that digital technologies enable teaching and learning tailored to the characteristics of both teachers and learners, and this is further enhanced and improved by the preferences and features available in information and communication technologies (ICT) tools. Through reviewing existing literature, it is evident that when teachers use computer models, simulations, and problem-solving activities in Life Sciences (Biology) lessons, learning becomes learner centred. Literature review indicates that the paradigm shift in pedagogical approaches helps learners think deeply about complex biology concepts (Elkhidir, 2020). In a study in South Africa by Ramnarain et al. (2023), findings show that the teachers predominantly held traditional rather than constructivist beliefs. The study showed that teachers' pedagogical beliefs impacted various aspects of teaching, including lesson planning, delivery, assessment, interactions with learners, and the incorporation of ICTs in learning.

The literature from a study in South Africa by Moyo (2019) focusing on instructional strategies which investigated the effectiveness of virtual realities, such as computer-based animations, on learners' content understanding in Life Sciences (Biology) was reviewed. Findings show that animated visuals improve Grade 10 learners' understanding of mitosis in South African township[2] schools. The study also revealed that using animations to teach Grade 10 Life Sciences (Biology) learners about mitosis may pose learning challenges. One of the challenges was that it was difficult for both the teacher and the learner to adapt to the sudden shift away from the teacher being the central figure in the classroom towards more interactions between learners (Moyo, 2019). Progress in electron microscopy has enhanced our understanding of biology; as a result, instructional methods have evolved to incorporate three-dimensional (3D) prototyping technology for creating tangible models. This advancement has ultimately

[2] A township is a place which is situated on the outskirts of urban areas and allocated limited land to accommodate large populations; the classification was done during the apartheid era and was enforced to segregate black South Africans (Monyooe, 2017).

revolutionised the teaching of cell division (Elkhidir, 2020). The advancement in educational technology had the stage; hence, this current study aimed to investigate the extent of the implementation of innovative instructional strategies in South African classrooms and uncover the challenges faced by Life Sciences teachers in South African classrooms.

Concentrating on the challenges teachers face in teaching mitosis topics; this section discusses the challenges found in the reviewed literature that led to teachers' challenges. A teacher has a significant role in fostering positive interactions to ensure that learning goals are achieved to the fullest extent (Miyatun et al., 2021). Nevertheless, teachers encounter difficulties in their efforts to teach Life Sciences (Biology) concepts proficiently. Teaching obstacles are elements that impede effective instruction (Daworiye et al., 2015). The reviewed literature shows that teachers experience several challenges in teaching in the classroom. These include planning issues (Yang et al., 2019), content mastery (Gaigher & Nxumalo-Dlamini, 2019; Kadarisma et al., 2019), selection and implementation of teaching strategies, teaching competencies (Osman et al., 2017; Rollnick & Mavhunga, 2017), and access to instructional materials (Widyawardana et al., 2021; Yurnetti et al., 2021). Challenges related to teaching Life Sciences (Biology) further include inadequate teaching time, which hampers the use of audio-visual materials (Sachyani et al., 2023). Other factors include the impact of electricity load-shedding (Matsheta & Sefoka, 2023) and overcrowding in the classrooms (Graham, 2023). Teaching is expected to take place in a structured way that considers the interests, traits, and circumstances of learners, aiming to accomplish learning goals effectively and efficiently (Miyatun et al., 2021). Both teachers and learners concurred that using authentic examples could enliven classrooms and help teachers foster robust interaction with their learners (Motseki et al., 2023).

CONCEPTUAL FRAMEWORK

Rollnick and Mavhunga's (2017) Pedagogical Content Knowledge (PCK) theoretical framework was used to guide the current research. Rollnick and Mavhunga's (2017) PCK theoretical frame was adapted from Shulman (1986) who first introduced the concept of Pedagogical Content Knowledge (PCK). Pedagogical Content Knowledge refers to the capacity to adapt content knowledge for educational purposes. Pedagogical Content Knowledge is the embedded knowledge acquired through practical experience. While the teachers' knowledge of the teaching content of a subject is not obvious to the eye, the PCK conceptual framework outlines five guidelines that make the teachers' PCK visible. Firstly, the visibility of PCK can be rated depending on the visual representations like pictures used by the teacher to aid learners' understanding of specific topics (Yadav & Berges, 2019); secondly, identification of the factors that make a topic easy or challenging (Rollnick & Mavhunga, 2017); thirdly, identifying learners' preconceptions or misconceptions about a topic (Yadav & Berges, 2019), Additionally, visibility of the teachers' PCK can be assessed by scrutinising the teachers' choice of teaching strategies for facilitating knowledge transfer to learners and finally, determining the teachers' understanding of the curricular saliency essential for learners to grasp a particular topic (Rollnick & Mavhunga, 2017).

RESEARCH DESIGN AND METHODOLOGY

A qualitative research design was followed, with an interpretive research paradigm. The interpretivist research paradigm expounded how interpretivists create an understanding of the social constructions of reality, using unspecified variables by examining from within, with data

presented in verbal form (Ikram & Kenayathulla, 2022). A qualitative approach aims to gather subjective viewpoints and thoughts, informing the current study. We used multiple case studies that involved investigating events, activities, processes, and individuals in South African classrooms. These cases are bounded by time and activity, and we gathered comprehensive information using various data collection methods over time (Creswell & Creswell, 2023).

Site and participants

The focus of the current study was on eight Life Sciences (Biology) teachers from five public secondary schools located in the one of the circuits in the Gert Sibande district in Mpumalanga Province, South Africa. The teachers were conveniently chosen because they taught the same subject and same grade within the same circuit, district, and province based on their availability and their geographical proximity to our location to facilitate easy access (Creswell & Creswell, 2023). Five schools participated in the study, with two schools categorised as Quintile 5 and three schools categorised as Quintile 2. In the South African context, schools are categorised into quintiles based on the socioeconomic status of the school, determined by factors like average income, unemployment rates, and literacy levels in the surrounding area (Dass & Rinquest, 2017). Quintile 5 schools are the wealthiest, and they receive the least amount of money from the government, while Quintile 1 schools are the poorest, and they receive the most amount of money per child. Pseudonyms were employed to safeguard the privacy and confidentiality of the teachers. The details of the teachers, including the schools, pseudonyms, gender and qualifications, are provided in Table 1.

Table 1:

Participants' Schools, School Quintile Statuses, Teaches' Gender and Qualifications Biography

School	Quintile status of the school	Teachers' pseudonyms	Gender	Qualifications
A	2	Emma	Female	BEd FET Life Sciences; Senior and Phase in Technology
A	2	John	Male	BEd FET in Life Sciences and Mathematics
B	2	Sarah	Female	BEd and ACE in natural sciences
B	2	Steven	Male	BEd FET Agriculture and Senior Phase natural sciences
C	5	Elizabeth	Female	BSc in human physiology,

				genetics, and psychology. Postgraduate certificate in education (PGCE)
C	5	Mary	Female	Secondary Teacher's Diploma (STD)
D	2	Precious	Female	Secondary Teacher's Diploma (STD)
E	5	Patricia	Female	BSc Microbiology PGCE specialising in Life Sciences

Data collection procedures

Two research instruments were used to collect the qualitative data: a lesson observation tool and a semi-structured interview schedule were self-developed for the teachers. We conducted semi-structured interviews via Zoom (an interactive video call programme) with five individual Grade 10 Life Sciences (Biology) teachers to ensure compliance with COVID-19 regulations. We asked the questions and the teachers answered the questions and the interviews were video recorded. The semi-structured interview schedule had 20 questions, each interview lasting 30 - 45 minutes. We conducted the interviews outside of school time so there was no interference with the school programmes. Prior to the interviews, we piloted the interview schedule. Conducting a pilot study allowed me to develop a deeper understanding of the observational context. This process improved my familiarity with the environment, enabling me to anticipate potential challenges and refine the study design as needed.

We employed purposive sampling to select eight teachers who took part in the present study. Through observing eight teachers teach mitosis topics, we employed purposive sampling to select eight teachers who took part in the present study. Eight hours are allocated by the CAPS document for teaching mitosis topic. According to the plan, three lessons each were supposed to be observed as each teacher taught. However, all the teachers taught the topic in one lesson except for one teacher (Patritia) who taught the topic over two periods. The lesson observation tool captured teachers' practices, prior knowledge, instructional strategies, and materials used for teaching chromosome structure and mitosis. Lesson observation also provided insights into the learning environment, including seating arrangements, learner characteristics, available resources, teachers' pedagogical styles, curricula, and classroom interactions (Loughland, 2019). After eight teachers were observed teaching, however; only five of the teachers consented to being interviewed. Interview schedules were crafted to investigate teachers' difficulties teaching mitosis, strategies for enhancing learners' academic performance in mitosis and identifying learners' challenges in understanding mitosis.

Data analysis procedures

The current study adopted an abductive strategy; it involves formulating explanatory or theoretical ideas based on careful examination of specific cases (Mitchell, 2018). Data analysis procedures commenced with data cleaning, organising and preparation, which entailed transcribing interviews that were both audio and video recorded using the Zoom social meeting application, scanning materials, reading field notes to remind us of the events that occurred during data collection, organising visual content, and categorising data based on its source (Creswell & Creswell, 2023). Following data cleaning, we read through the transcribed data, writing important notes as we came across striking data. Data coding occurred by grouping text portions and writing a word representing a category. Content analysis is the interpretation of the meaning or content of communication or text (Ikram & Kenayathulla, 2022). I conducted content analysis in two distinct phases. Initially, I focused on the surface or explicit content, which entailed examining the data through the lens of the codes I had established from transcribed materials. The content analysis of the codes led to categories, sub-themes and eventually, themes that showed various viewpoints from different individuals, incorporating a range of quotes and specific evidence (Creswell & Creswell, 2023; Ikram & Kenayathulla, 2022). The lesson observation data led to a thematic analysis that yielded rich descriptions.

Quality assurance of the lesson observation tool and interview schedule was enhanced by establishing crystallisation and trustworthiness. Crystallisation means creating a thorough understanding of a topic by gathering numerous details in different ways (Ellingson, 2009). This approach helps researchers see patterns and themes in a broader context, giving a fuller picture of what is being studied. We used multiple case studies that enabled the collection of data by observing eight different cases, which ensured that saturation of data was reached. Trustworthiness was confirmed by focusing on credibility, dependability, conformability, and transferability (Polit & Beck, 2018). Credibility was guaranteed by providing rich descriptions of social processes and interactions, while dependability was enhanced by maintaining an audit trail of the researcher's journal, lesson observation checklists and transcribed interview data and Atlas.ti report were submitted and stored at the University of Pretoria under the identifier http://hdl.handle.net/2263/99185. The audit trail reporting detailed process of the research, along with the maintenance of analysed data and findings to facilitate replication of the present study (Alharahsheh & Pius, 2020). Conformability, on the other hand, was ensured by verbatim notes as seen in the discussion of the interviews to ensure that participants' voices were reflected. Finally, we provided sufficient descriptive data in the current study report so that consumers can evaluate the applicability of the data to other contexts to ensure transferability.

Ethical considerations

We ensured that participants' needs, rights, values, and desires were respected. The following measures were implemented: teachers willingly provided consent to participate in the study by signing forms and indicating their voluntary participation in the research study. We explained the research objectives verbally and in writing to ensure understanding, including how data will be utilised, informing participants about all data collection methods and activities, providing participants with verbatim transcriptions, prioritising participants' rights, interests,

and preferences when making decisions about reporting the data; and allowing participants to decide on anonymity. Furthermore, all the ethical issues stipulated in the research data management policy of the University of Pretoria were adhered to (University of Pretoria, 2023). Ethical clearance (certificate number EDU086/21) was granted by the University of Pretoria ethics committee to commence with the study.

FINDINGS AND DISCUSSION

Findings from lesson observations and interviews are presented in the following sections. The first part of the lesson observations regarded the classroom context. In the eight cases, disparities in technology access and visual aids were evident across the five school sites within the classroom settings. In the two school sites falling under Quintile 5, namely School Sites C and E, the classrooms were equipped with both whiteboards and smart boards. Both schools had computers that were linked to the smart boards. Three teachers, Elizabeth, Mary and Patricia used computers and the teachers remained in their assigned classrooms while the learners rotated when transitioning between lessons. Since only three participants integrated technology, these observations are similar to the results obtained in the study of Masingila et al. (2019) that showed that only a few teachers integrated the use of technology. Although teachers have digital competency and skills in using technology resources, results indicate that few teachers use technology as a tool or medium to transmit new skills, knowledge, and understanding of a concept or phenomenon in their classrooms. In the Quintile 2 school sites, which included School Sites A, B, and D, different contexts were observed. Here, the teachers rotated between the classrooms while the learners remained in their assigned classrooms. Consequently, the teachers had limited opportunities to personalise the classroom environment according to their preferences. Kiliç et al.'s (2016) research suggest that variations in the teaching context of mitosis influence the understanding of mitosis-related topics and concepts among learners. Kiliç et al.'s (2016) findings also highlight that even when the instructional content is the same, disparities in the learning environments play a role in shaping learners' understanding of Life Sciences (Biology) concepts.

Lesson observations

Eight Grade 10 Life Sciences (Biology) teachers were observed teaching mitosis. We examined how teachers are applying innovative instructional strategies recommended in the existing literature and the content they utilise when teaching mitosis. Additionally, we investigated the interactions among learners, their teachers, and the instructional materials provided by the teachers. Next, we describe observations made from each of the observed cases. The five components of the PCK that were examined using the observation tool encompass; first, representations such as visuals, comparisons, patterns, and graphics help simplify or challenge topic comprehension (Yadav & Berges, 2019). Second, teachers identifying easy and difficult aspects of the subject matter (Rollnick & Mavhunga, 2017). Third, understanding learners' preconceptions and prior knowledge is crucial for addressing misconceptions (Yadav & Berges, 2019). Fourth, selecting effective teaching strategies ensures successful knowledge transfer. Finally, curricular saliency emphasizes the core concepts that learners must grasp in a given topic.

The participants exhibited good practices during lesson observations

In all cases, the participants started their lessons with a clear introduction to the topic of mitosis. All eight participants consistently explained important scientific terms and concepts related to mitosis. Kalas and Redfield (2022) have highlighted that there is a notable similarity in the sound of specific Life Sciences (Biology) terms, such as mitosis/meiosis, centromere/centrosome/centriole, and chromosome/chromatid/chromatin. The resemblances of the Life Sciences (Biology) terms can potentially create difficulties in learning these terms, particularly when teachers promote rote memorisation among learners (Kalas & Redfield, 2022). Machová and Ehler (2023) found that Czech learners often struggle with basic terms such as gene, chromosome, allele, meiosis, and mitosis.

In the current study, each of the eight participants employed teacher-centred methods, specifically teacher exposition or explanation, for imparting knowledge about Life Sciences (Biology) terms. The strategies and instructional materials adopted by teachers are important in determining learners' learning outcomes (Luwoye et al., 2021). Taylor (2019) cautions that unless there is a substantial enhancement in teachers' disciplinary expertise and pedagogical skills, all other endeavours to enhance the quality of education in South Africa may encounter limitations in their effectiveness. Luwoye et al. (2021) argue that lack of instructional materials during instruction makes learning of mitosis difficult.

Seven teachers made an effort to connect the new material on mitosis to what learners already knew. Of these seven participants, three are commended for effectively incorporating prior knowledge into the teaching and learning of topic of mitosis. The other four participants superficially incorporated the prior knowledge, there was a weak link between the previously taught material and the topics of mitosis making it challenging for learners to integrate and retain information (Nadelson et al., 2018). One participant (Mary) did not make an effort to incorporate prior knowledge. Challenging the learners' prior conceptions helps learners construct their understanding (Buma & Nyamupangedengu, 2020).

Five participants (Emma, John, Sarah, Elizabeth and Precious) used analogies to explain complex concepts. Analogies helped make abstract ideas more relatable and understandable. However, in some cases where analogies were used, they were sometimes inappropriate or not fully explained. Teachers are praised for using analogues since researchers indicate that analogical thinking plays a role in creative discovery, problem-solving, categorization, and learning and transfer (Gentner & Smith, 2012). However, caution has to be taken to ensure that appropriate analogies are used to prevent misconceptions or confusion from developing in learners (Kim et al., 2023). Analogies could serve as powerful learning tools that prompt more learners to ask questions and clarify the content (Aranda et al., 2018; Buma & Nyamupangedengu, 2020). Reviewed literature of Venville and Treagust (1996) recorded four examples of analogues that have been used in Life Sciences (Biology) education. The four analogues include the supermarket analogy for classifying living things (Posner et al., 1982), the car cooling system analogy for human temperature homeostasis (Vosniadou, 1994), the fluid mosaic analogy for cell membranes learning that was used as a transformer, (Chi et al., 1994) and the bucket, pump analogy for teaching the heart's structure, function (Pintrich et al., 1993) motivational perspective of conceptual change.

All eight participants highlighted the importance of mitosis, including its role in the growth, and repair of worn-out tissues. However, three of the participants overlooked explaining the importance of mitosis in asexual reproduction. Reviewed literature indicates that some factors related to teachers' capacity, notably the lack of subject matter content knowledge, impede the learning of difficult topics such as mitosis (Byukusenge et al., 2023).

Seven participants made use of static visual representations from diagrams in textbooks and handouts, which four of the participants heavily relied on for the delivery of the topic of mitosis. Half of the participants used diagrams in the textbooks, while the other half used handouts. Teachers and educational and instructional designers often create these visual representations for teaching and learning (Fadiran et al., 2020). However, Mary and Elizabeth showed the diagrams of chromosomes on slides, while Patricia used a document viewer to cast a diagram of the chromosome on the white screen. Elizabeth further used learners to demonstrate chromosome structure. Patricia built chromosomes from moulding clay and demonstrated the chromosome movement during the phases of mitosis. Two participants (Elizabeth and Patricia) engaged learners in interactive learning activities. Four of the participants (John, Patricia, Elizabeth and Precious) were proactive in addressing common misconceptions and challenges that learners might face. This included clarifying the distinction between centromere and centriole and correcting misconceptions about interphase being a phase of mitosis. Five of the participants (John, Mary, Steve, Elizabeth and Patricia) introduced the use of the acronyms or mnemonics (PMAT) to help learners remember the phases of mitotic division. Acronyms can aid memory retention. According to Putnam (2015), acquiring and consistently using mnemonics is a valuable long-term investment. A learner who masters mnemonic techniques in high school can employ methods like keywords and the peg system during college to recall scientific terminology.

Five participants (Emma, John, Sarah, Precious and Patricia) related the concept of mitosis to real-world scenarios, making the topic more relatable and applicable to learners' lives. The other three participants could not incorporate real-world scenarios that the learners could identify with. Seven participants were mindful not to overwhelm learners with information beyond the scope of their grade level, except for Elizabeth. Teachers at every educational level are advised to take into consideration their learners' cognitive development stage. Knowing their learners' cognitive development stages allows teachers to plan the right amount of content to prevent overwhelming their learners (Haskel-Ittah & Yarden, 2018). Five of the participants had knowledge of content that was related to mitosis teaching but did not intend to teach that content during the teaching of the topic of mitosis. They recognised the need to differentiate between what should be taught at Grade 10 and what should be covered in higher grades.

Poor educational practices exhibited by the participants during lesson observations

The integration of prior knowledge with the topic of mitosis was done at a surface level, with some teachers, like Sarah, Steve, Emma and Patricia (Mary did not incorporate prior knowledge), failing to incorporate any of the learners' prior knowledge. Scheiter et al. (2018) contended that learners who possessed prior knowledge about mitosis tended to grasp and process mitosis-related information more effectively compared to learners who lacked the necessary prior knowledge for understanding mitosis. Prior knowledge is important for the

construction of new knowledge as it is recorded in literature that conceptual change is an ongoing process involving both the enrichment of existing knowledge and the complex task of revising deeply rooted framework theories (Vosniadou, 1994). It is the responsibility of teachers to provide learners with opportunities and challenges to build knowledge of related concepts (Rahim et al., 2020). Moreover, teachers need to actively challenge learners' previous ideas during the lesson and reconstruct the connections they established between the basic Life Sciences (Biology) concepts (Haskel-Ittah & Yarden, 2018).

Chromosome structure was a problematic concept for the teachers to explain during lesson delivery. Chromosome structure was inadequately taught. Half of the participants illustrated both a replicated chromosome and a non-replicated chromosome, while the other half of the participants taught about a replicated chromosome only. The teachers needed to present both types of chromosomes to the learners. Reviewed literature indicate that when learners fail to conceptualise chromosome structure adequately, they fail to discriminate between chromatids and chromosomes (González & Rossi, 2016; Hubbs et al., 2017).

Most of the participants (seven) demonstrated misconceptions themselves, which could be passed on to learners. Many researchers have shown that learners already hold numerous misconceptions about the Life Sciences (Biology) topics, and they often lack a deeper understanding of the Life Sciences [Biology concepts] (Awang-Kanak et al., 2016; Krishnamurthy, 2017; Luksa et al., 2016). For teachers to add more misconceptions and confusion to learners is a substantial oversight. Six lessons lacked active learning strategies, such as hands-on activities, group discussions, or interactive exercises. This passive teaching approach can limit learner engagement and hinder comprehension. Furthermore, Barman and Bhattacharyya (2015) encourage teachers to use instructional strategies that allow learners to ask questions, explore, and assess what they already know.

Lesson observations suggested that some teachers were not thoroughly prepared for their lessons. Six participants lacked clarity in their explanations and questions, making it difficult for learners to understand and engage effectively. While the majority of the teachers exhibited some confusion and mixing up of terminology and concepts, Emma's case was conspicuous in that regard. Emma's lesson particularly lacked a clear and organised structure. Literature confirms that teachers tend to place blame on learners when they are unable to exhibit the expected behaviours at the end of a lesson or examination rather than reflecting on their role in utilising appropriate and effective instructional methods (Ibrahim et al., 2020).

There is a general lack of use of interactive instructional materials. In some cases, learners did not have access to essential materials, such as textbooks (Emma's class), handouts (Emma's and Precious' classes) or manipulative materials (six classes: Emma's, John's, Steven's, Mary's, Sarah's, and Precious' classes). This hindered learners' participation in the lesson and affected their learning experiences negatively. Sachyani et al. (2023) indicated that teachers frequently voiced their worries regarding the absence of instructional resources and tools for instructing Life Sciences (Biology) in educational institutions. The instructional strategy employed in eight cases was primarily exposition and explanations. Diversifying teaching strategies and fostering learner engagement were lacking. The literature reviewed indicated that the predominant instructional methods in Nigeria are teacher-centred, with learners playing a passive role in the learning process. This approach has contributed to the poor

performance of learners in Life Sciences (Biology) in Nigeria (Yaki et al., 2020). Furthermore, Kistian et al. (2017) have also shown that teachers present information without any verbal interaction with learners.

While some teachers used visual aids, their effectiveness varied. In some cases, visual aids were not adequately explained to learners or interacted with in teaching. In other cases, the visual aids were static and were inadequate in explaining the dynamic aspects of the chromosomes' movement to the equator during metaphase and to the centrioles/ poles during anaphase (Yang et al., 2018). There were limited interactions among learners in these cases, and questions often required simple recall answers. Buma and Nyamupangedengu (2020) also confirm that simply using a large number of questions does not necessarily lead to effective instruction if the classroom talk does not support a deep understanding of the academic content. Finally, in five cases, no assessments or tasks were given to learners during the observed lesson. Document analysis showed that assessments were given during subsequent lessons after the observed lessons. Assessments can help reinforce learning and gauge learner understanding.

Interviews

Five of the eight teachers (who were observed teaching) agreed to participate in the interviews. The semi-structured interviews were used to establish 'The challenges teachers experienced when teaching mitosis'. The findings from interviews are reported based on the main theme (Theme 1) that emerged, see Table 2.

Table 2:

Summary of the theme, sub-themes and categories that emerged from the teachers' interviews

Theme 1: The challenges that teachers experienced when teaching mitosis	
Sub-theme 1.1: Nature of the challenges experienced by the teachers and their proposed strategies to address it	
	Category 1: Instructional materials, technology and infrastructure Category 2: Workload Category 3: Time factor Category 4: Overcrowding of classes Category 5: Attitudes of teachers and learners towards mitosis Category 6: Mitosis content and terminology
Sub-theme 1.2: External factors contributing to the challenges experienced by teachers when teaching mitosis	
	Category 1: Socioeconomic statuses of the learners
	Category 2: Vandalism/ lack of repair of infrastructure, electric cables and plugs and electricity issues
	Category 3: Under-resourced schools

When teachers were asked about 'The challenges they experienced when teaching mitosis', two sub-themes emerged, namely the 'Nature of the challenges experienced by teachers when

teaching mitosis', and 'External factors contributing to the challenges experienced by teachers when teaching mitosis'.

Sub-theme 1: Nature of the challenges experienced by teachers when teaching mitosis

Interviews with teachers highlighted challenges they encounter when teaching mitosis, including insufficient instructional materials, heavy workload, time constraints, overcrowded classrooms, and negative attitudes from both teachers and learners towards mitosis, as well as difficulties with mitosis content and terminology.

Instructional materials, technology and infrastructure

All participants interviewed expressed a shortage of necessary instructional materials, technology, or infrastructure essential for effective teaching. Sarah mentioned experiencing a shortage of resources such as posters or a smart board. Sarah elaborated on the challenges of the lack of a laboratory for Life Sciences (Biology). Regarding insufficient resources, Elizabeth clarified that her specific challenge at her school was the shortage of paper for printing study guides. She also highlighted that they did not have enough microscopes for the learners. Emma mentioned that they did not have enough resources as a school to help the learners try to create experiments which could demonstrate mitosis. Precious lamented that they lacked alternative power to photocopy some handouts during load-shedding. Patricia pleaded with the Department of Basic Education (DBE) to supply them with moulding clay for making models. The reviewed literature revealed that teachers linked the challenge of creating effective teaching environments due to shortages of instructional materials (Byukusenge et al., 2023; Ramabulana & Sedumedi, 2017). Similarly, the results of the present study align with those of Sachyani et al. (2023), who found that teachers in Israel frequently voiced concerns about the lack of materials and equipment needed to teach molecular biology in schools.

Furthermore, the reviewed literature shows that several school-related factors and teaching challenges influence Life Sciences (Biology) teaching. These factors include teachers' unclear presentation of material and the limited variety of instructional strategies (Husna et al., 2023). If schools have adequate facilities that learners can utilise, the learning process can be enhanced, leading to a reduction in learners' difficulties (Husna et al., 2023). Enhancing the learning process will eventually improve the teachers' enthusiasm for teaching and address the lack of instructional materials, technology, and infrastructure (Zaky, 2020). Four teachers requested that DBE supply schools with new technology gadgets such as iPads, whiteboards, overhead projectors, slides, smart boards, and videos.

Workload

Two teachers cited the issue of workload as an impediment to their effective teaching. Precious disclosed that teachers are struggling due to teaching many classes in Grade 12 and also Grade 10. She hinted that teachers, including herself, who teach Grade 12 Life Sciences (Biology) tend to prioritise Grade 12 instruction over Grade 10 teaching, resulting in less attention being devoted to Grade 10 instruction. Another teacher, Emma, indicated her desire to obtain assistance from experienced teachers. However, she emphasised that the large number of learners in her school caused teachers to be overworked, leaving no time for experienced teachers to support the less experienced teachers. Emma explained that the heavy workload of the teachers created by overcrowded classrooms prevents her from receiving

support from experienced teachers due to a shortage of time. Results obtained from this current study resonate with Ndethiu et al.'s (2017) study that revealed that overcrowded classrooms lead to teachers being overwhelmed by the workload. Two teachers suggested the employment of more teachers to reduce the workload.

Time factor

All the teachers complained about the time for teaching mitosis. Precious highlighted that mitosis is often taught towards the term's end, requiring thorough coverage of the material. The ATP and pacesetter documents specify the weeks and dates for teaching Life Sciences (Biology) topics, adherence to which is crucial to avoid falling behind, leading to incomplete topic coverage before formal assessments. A study carried out in Malaysia shows that limited time hinders the effective teaching of the topic of mitosis (Osman et al., 2017). Time is a limiting factor in mitosis teaching in Malaysia and South African secondary schools. Furthermore, the literature examined showed that teachers in Israeli high schools often expressed concerns about the lack of time for teaching abstract topics adequately (Sachyani et al., 2023). Three teachers proposed more time to be allocated in the annual teaching plan (ATP) to address limited-time challenges, emphasising that struggling learners needed more time to grasp the mitosis topic.

Overcrowding of classes

All the participants mentioned overcrowding as a limiting factor to the effective teaching of mitosis. Sarah's statement indicates that overcrowding had the disadvantage of reducing individualised assistance given to learners. Precious added to the concern of overcrowding by reiterating,

Our classes are overcrowded; you cannot pick out the learners who are struggling unless you give them a written task or an assessment.

Patricia echoed the same sentiments,

learners would easily slip through the cracks if they were part of a large group. They let other people do the work and ride along and not be involved.

Emma raised concerns that overcrowding in the classrooms denies senior teachers time to support novice teachers:

With the numbers that we have, there's a large number of learners, so I don't think there is enough time.

These concerns raised by teachers about overcrowding are similar to observations made by Graham (2023) in South Africa, where overcrowded classrooms led to diminished personalised interactions with learners, neglect of instructional strategies, and poor time management. Ndethiu et al. (2017) suggest that class overcrowding leads to teachers dealing with significant workloads, such as grading, a lack of individualised attention for learners and shortages of instructional materials such as textbooks. Encouraging learner engagement in a crowded classroom demands considerable effort as it poses a challenge. (Dhawan, 2020). Five teachers suggested that overcrowding of classes could be solved by the government

building more schools and providing mobile classrooms to address the issue of overcrowding in schools.

Attitudes of teachers and learners towards mitosis

Elizabeth highlighted that

if a teacher is forced into [teaching] Life Sciences (Biology) and she doesn't want to teach that subject, it can also cause the teacher to lose the motivation to teach.

Teachers forced to teach a subject they are not qualified for can display negative attitudes toward teaching that subject. Sarah also indicated that because of the difficult nature of the topic of mitosis, she 'does not do justice' in teaching the subject. Reviewed literature indicates that teachers generally find it more convenient to teach theoretical concepts rather than create instructional materials for Life Sciences (Biology) education, a negative attitude that undermines the benefits of improvisation of instructional materials in cases of shortages (Enenya & Muhammad, 2018). Enenya and Muhammad's (2018) study showed that the majority of respondents had a negative attitude towards the improvisation of instructional materials; the respondents agreed that improvisation can be a laborious task. For that reason, they preferred the teacher exposition or lecture method of teaching. In addition to the teachers' negative attitude towards the topic of mitosis, learners display another attitude of lack of motivation to excel in the subject of Life Sciences (Biology). Elizabeth noted,

[As teachers] we struggle with the learners' determination. Many learners opt for Life Sciences (Biology), assuming it is an easier subject.

Precious echoed Elizabeth's sentiment, stating that learners select Life Sciences (Biology) without the determination to excel and are influenced by their friends' choices. One approach to addressing the negative attitudes of teachers and learners towards mitosis involves ensuring that teachers are adequately equipped and qualified for the subject. Three teachers suggested that the schools take responsibility for providing proper in-service training and recruiting teachers qualified to teach Life Sciences (Biology) to ensure that teachers have the correct attitude required for effective teaching of Life Sciences (Biology).

Mitosis content and terminology

Two interviewed participants raised the issue of content sequencing as leading to challenges in the teaching of mitosis topics. Patricia explained that mitosis is taught in Grade 10 while meiosis is taught in Grade 12, and this gap negatively affects the retention of information in learners. During discussions with teachers about terminology challenges, Sarah mentioned,

One challenge is that learners struggle with understanding new terminology introduced during mitosis lessons.

Similarly, Sarah echoed Precious' sentiment, stating that subsequent lessons are hindered as they repeatedly explain biological terms introduced during mitosis teaching. The literature reviewed indicates that teachers experience difficulties teaching Life Sciences (Biology) topics because learners struggle with comprehending scientific terminology (Husna et al., 2023). Lesson observations also confirmed that five teachers struggled with mitosis terminology. The teachers used Life Sciences (Biology) terms interchangeably, potentially introducing confusion

to learners. Emma used the terms cell cycle and mitotic division interchangeably while John on the other hand displayed a misconception of using the terms gene/allele and centromere/centriole interchangeably. Machová and Ehler (2023) highlighted a common problem: the interchange of basic terms such as gene, chromosome, allele, meiosis, and mitosis, leading to learners' confusion in life science terminology. While it is important that progress and changes are occurring in life, it is equally important for the curriculum to undergo periodic revisions to include technological changes occurring in the schools, communities and societies; professional development should also continuously occur to assist teachers dealing with their content and terminology challenges (Husna et al., 2023). Two teachers suggested content restructuring as a measure to address content structuring and terminology challenges, and they suggested discussing terminology at the start of a topic so that learners understand the terminology before the mitosis topic is taught.

Sub-theme 1.2: External factors contributing to the challenges experienced by teachers when teaching mitosis

The socioeconomic statuses of the learners, vandalism/lack of infrastructure repair, electric cables and plugs and electrical issues, and under-resourced schools are the external factors identified by teachers as contributing to the challenges of teaching topics of mitosis.

Socioeconomic statuses of the learners

Elizabeth revealed that

[English class learners] cannot access the study guides themselves when at home or when trying to study.

In contrast, the Afrikaans medium learners have internet access and study at home. In the reviewed literature, Taylor (2019) postulates that the inequitable distribution of disciplinary knowledge resources is one of the primary sources of the significantly weaker outcomes exhibited by South African children from poor homes. Emma suggested that

extra classes could be organised for the struggling learners.

Then she quickly explained that

Learners who are heads of child-headed families will not be able to come to the extra classes. They cannot because some of them are heading certain families, so it is a very difficult question to answer.

Husna et al. (2023) argue that parents' income plays a significant role in shaping children's learning experiences. Adequate financial resources ensure that children have access to necessary learning materials and tools, reducing difficulties during studying. Socioeconomic challenges affect a parent's ability to establish support systems and maintain a child's well-being. Consequently, learners from disadvantaged families often face compromises and are more prone to developing negative perceptions of themselves when being taught specific subjects (Nogobo & Kalariparampil, 2023).

Vandalism/ lack of repair of infrastructure, damaged electric cables and plugs and electricity issues

Sarah mentioned the problem of damaged electrical lines due to vandalism as one of the challenges affecting the teaching of mitosis. A lack of electric wires and plugs in the classrooms due to vandalism or lack of repair, together with the lack of internet in the school, leads to a lack of effective use of technology by the teachers. Precious complained about the lack of alternative power sources for photocopying machines during electricity load shedding. Similar findings were obtained by Matsheta and Sefoka (2023), whose study showed that the absence of electricity adversely affects the overall academic performance of the school. Two teachers expressed frustrations caused by electrical load-shedding. Sarah and Precious mentioned that load-shedding discouraged them from using their laptops and Precious further explained that load-shedding prevented her from photocopying the handout for teaching.

Under-resourced schools

Emma lamented,

Public schools are under-resourced, where you can't give them a video to help them see the phases of mitosis.

Precious advocated for:

The supply of up-to-date technology, the iPads that they [DBE] are giving to learners in Gauteng. Maybe if they [DBE] can come, also to our school, and put whiteboards instead of having the chalkboards and the chalk so that we can use slides and overhead projector or videos so that learners can see mitosis cell[s].

Research has suggested that in cases of lack of resources, teachers can improvise (Awolaju, 2015; Upelle et al., 2019; Yaki et al., 2020). However, it has also been revealed in the literature that the reluctance of teachers to use improvised instructional materials in teaching is often attributed to laziness. This viewpoint arises because preparing visual aids can be labour-intensive, leading many teachers to abandon their use shortly after completing their training. A dedicated teacher, however, should be willing to improvise when necessary, even in the absence of readily available instructional materials (N. Ibrahim et al., 2021). Furthermore, the literature reveals that effective teaching requires a teacher who is knowledgeable of the content and pedagogy (Sehole et al., 2023).

RECOMMENDATIONS

Based on the findings of the current study that investigates the instructional strategies and content used by teachers to teach the topic of mitosis in Life Sciences (Biology) classrooms in Mpumalanga, South Africa, the following recommendations are put forth: ESKOM[3] and municipalities need to inform people better about load shedding schedule and also reduce load-shedding. There is a need for the DBE to intervene by investigating the availability of instructional materials and supplying sufficient instructional materials and technological gadgets in cases of shortages. They must help teachers in the schools reduce heavy workloads, consider reducing Grade 10 content to deal with time constraints, restructure the content, and

[3] ESKOM, a state-owned enterprise in South Africa, is responsible for supplying electricity nationwide (Mashilo & Kgobe, 2023).

reduce gaps between the teaching of related topics. They must build more classrooms and schools to alleviate overcrowding in classrooms and support workshops to address teachers' negative attitudes towards the Life Sciences (Biology) subject of the teachers and learners. Curriculum development professionals of the DBE need to conduct research to establish reasons for difficulties inhibiting teachers from effectively incorporating learners' prior knowledge. Life Sciences (Biology) teachers require training in innovative modern instructional strategies to increase their confidence using modern teaching tools.

LIMITATIONS OF THE STUDY

The current study was a qualitative research project, which meant that the samples were small and not representative of the population. Further research could be conducted using quantitative research methods that make use of larger samples to generate generalisable conclusions. Secondly, the sampled schools belonged to Quintiles 2 and 5; further research could be conducted by sampling schools from all five quintiles for fair comparisons. Thirdly, the study was cross-sectional, and a longitudinal study could provide findings on the impact of using instructional materials by teachers on learners' academic achievement in Life Sciences (Biology) in the South African context. Fourthly, no tests were run to establish if there was a relationship between the qualifications of the teachers to their content knowledge.

CONCLUDING REMARKS

The study investigated the content, instructional materials and instructional strategies used by Grade 10 Life Sciences (Biology) teachers in the teaching of the topic of mitosis in South African. Findings from observations and interviews were analysed together, showing that teachers predominantly utilised teacher-centred instructional methods, especially direct exposition or explanation, for teaching mitosis topics (I. Ibrahim et al., 2020). Secondly, inconsistencies in the content taught existed among the teachers, with some teachers teaching chromosome numbers while others did not teach chromosome numbers (Krishnamurthy, 2017; Stern et al., 2020). Thirdly, teachers at Quintile 5 schools integrated technology into teaching the topic of mitosis, while teachers from Quintile 2 schools used handouts and textbooks as instructional materials. Lastly, limited social interactions occurred in all the classes observed. Teachers from the Quintile 5 schools also integrated the active involvement of learners in the teaching and learning process (through the construction of models and demonstration using the learners). Teaching on the topic of mitosis is hindered by the limited innovative instructional strategies and instructional materials, along with teachers having limited PCK. There is a need to promptly address these identified challenges by implementing interventions early on to prevent any negative impact on the instruction of topics such as reproduction and meiosis in Grade 12. There is a need to promptly address these identified challenges by implementing interventions early on to prevent any negative impact on the instruction of mitosis topics at Grade 10 level that are fundamental for the effective teaching of topics such as reproduction and meiosis in Grade 12. Future research could focus on establishing if there was a relationship between the qualifications of the teachers in relation to their content knowledge.

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