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TEACHERS' PREPAREDNESS AND EXPERIENCES IN TEACHING MEIOSIS TO GRADE 12 LEARNERS IN LIMPOPO PROVINCE

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Abstract

Over the years, learners have failed to perform satisfactorily in the final examinations in Grade 12 Life Sciences in South Africa. Examination reports have consistently cited the poor performance by learners in questions on meiosis and related topics. In a qualitative case study research design, three Life Sciences teachers were purposively selected to determine their preparedness and experiences in teaching meiosis to Grade 12 learners. Data collection involved administration of a test on meiosis, observation of each teacher four times whilst teaching meiosis and interviewing each teacher once. Teachers' test scores were analysed using descriptive statistics and observations and interviews were coded manually. The findings showed that only one teacher possessed satisfactory levels of the content required to teach meiosis and was very versatile in her teaching. One teacher relied heavily on the textbook, the other employed teacher-centred approaches. The findings provide implications for in-service teacher professional development.

Keywords: *Meiosis, life sciences, teacher preparedness, teacher experiences.*

1. Introduction

In this paper we seek to determine teachers' preparedness and experiences in teaching meiosis to Grade 12 learners. Notably, teachers' efficacy in making concepts accessible to the learners is of paramount importance. Based on such imperatives, the current study draws from Botha and Reddy (2011)'s postulation that good teaching entails a deep and comprehensive knowledge of subject matter knowledge and an understanding of alternative ways of presenting such knowledge to learners. In this case, the teachers' knowledge and understanding of meiosis and their abilities to devise and deploy the pedagogical resources appropriate to teaching such concepts is important.

According to the National Senior certificate 2018 Diagnostic Report, performance of learners in Life Sciences final examinations has not shown any significant improvement particularly for 40% and above achievement level. In fact, there was a decline from 52.1% to 51.7% for learners in this category from 2017 to 2018. Learners' performance on meiosis and reproduction were way lower compared to other topics in the 2018 Life Sciences Examination Paper 1.

Research in South African schools, showed that teachers were still using direct transmission (chalk and talk) as a way of teaching (Rogan, 2004). In order for learners to understand concepts of meiosis, and to allow learners to expand their knowledge and observe the relationships between related concepts to meiosis, it is important that the science teacher acquires knowledge in multiple areas to ensure those concepts are integrated by using a variety of teaching strategies and instructional methods (Botha & Reddy, 2011). The purpose of the current study was to determine teachers' preparedness and experiences in teaching meiosis to Grade 12 learners. The following research questions guided the study: 1. How well prepared are teachers to teach the topic meiosis to Grade 12 learners? 2. What are the teachers' experiences in teaching meiosis to Grade 12 learners?

2. Literature review

Previous studies have proved that the concept of meiosis is so difficult that even university students find it very challenging to understand (Murtonen, Nokkala & Södervik, 2018). The difficulties these students experience, might have emanated from the way they were taught the same topic in their high school years. Teachers may transfer their misconceptions to their learners (Hashweh, 1987). According to the South African Curriculum and Assessment Policy Statement (2011) the concepts on meiosis start from Grade 10 with the cell structure and function and the role of organelles; and in Grade 12 with DNA as the code of life, and meiosis which then further extends to gametogenesis under the topic Human Reproduction.

In a study to examine major sources of misconceptions and learning difficulties in genetics amongst school learners, Longden (2010) found that some learners' misconceptions were related to the nature of the concepts in genetics, such as the frequent representation of meiosis by fixed inanimate stage diagrams. These problems could also be pedagogical in nature in that the time between the presentation of some of the concepts in meiosis and those in genetics is too wide that learners forget and fail to make connections (Longden, 2010). In a study to examine difficulties Biology teachers face in teaching cell division in the secondary schools in Turkey, Öztap, Özay and Öztap (2003) found that biology teachers perceived cell division as one of the most difficult topics. In particular, teachers isolated meiosis as the most complex concept to teach compared to other concepts on cell division.

3. Conceptual framework

The study used Pedagogical Content Knowledge (PCK) as the lens through which teachers' preparedness and experiences could be assessed and interpreted. This is because PCK is the ability by teachers to transform the subject matter knowledge they possess into powerful pedagogical forms (Shulman, 1987). The researchers adopted Mavhunga's (2012) Topic Specific Pedagogical Content Knowledge (TSPCK) model to explicate the teachers' transformation of the concepts on meiosis. PCK is both an external and an internal construct, as it is constituted by what a teacher knows, what a teacher does, and the reasons for a teacher's actions.

4. Methodology

The study employed a qualitative case study research design which shares its philosophical foundation with the interpretive paradigm. The interpretive paradigm supports the view that there are many truths and multiple realities. As observed by Schwandt (2011) this type of paradigm focuses on the holistic perspective of the person and environment which is more congruent with the worldview studies.

4.1. Selection of participants

Using purposive sampling technique, three Life Sciences teachers from three different schools of Limpopo province were selected. These teachers had taught Grade 12 Life Sciences for more than three years in which meiosis is one of the topics. Within three years of teaching meiosis, teachers should have developed and established the competency in teaching the topic. Table 1 shows the three teachers' profiles.

Table 1. Teacher profiles.

	Teachers' pseudonyms		
	Bridget	John	Sarah
Gender	Female	Male	Female
Age	51	34	54
Qualification	Diploma	Bachelor of Education	Diploma, Bachelor of Arts & BEd honours
Teaching experience	26	7	28
Experience in teaching Grade 12	5	3	11

4.2. Data collection and analysis

Multiple methods of data collection were used to ensure methodological triangulation (Merriam, 1998). A test was first administered to the three teachers to determine their conceptual understanding of meiosis. The test required teachers to demonstrate their knowledge of meiosis as they differentiated, illustrated, identified and explained chromosomes under different stages of meiotic division. Test items came from activities in the textbooks teachers used to teach Life Sciences to Grade 12 learners. Secondly, each teacher was observed four times whilst teaching different concepts on meiosis. Non-participant observation method was appropriate as it allowed observation of teachers' practices in "real life" classroom contexts (Genzuk, 2003). Thirdly, each teacher was interviewed once using a semi-structured interview schedule to get clarity especially on the issues that the researchers did not understand during classroom observations. Analysis of documents such as teachers' lesson plans for each teacher was done. Data analysis involved descriptive statistical analysis of the test scores and coding of data from interviews and lesson observations using Saldana (2009) manual. The different teacher knowledge domains in the TSPCK model (Mavhunga, 2012) were used to assess how well-prepared the teachers were to teach the topic. Validation of the findings were done through member checking.

5. Findings

The findings are presented in three sections that follow.

5.1. Teachers' preparedness in teaching meiosis to grade 12 learners

Table 2 shows the teachers' scores in the test they wrote on some concepts on meiosis, which shows a wide range between the three teachers' performance.

Table 2. The three teachers' scores obtained from the test on meiosis.

	Teachers' scores	
	Out of 55	Percentage
Bridget	17	31
John	31	56
Sarah	51	93
Average	33	60

From the table it shows that both Bridget and John had poor content knowledge regarding meiosis and only Sarah possessed satisfactory levels of the content required to teach meiosis to Grade 12 learners. From the test scripts it was evident that Bridget only answered questions whose answers she knew and avoided any questions with unfamiliar content. Her reason was,

> I did not prepare for this test because it is not my responsibility as a teacher to know what is in the textbook. I am not the one who will be writing the examinations at the end of the year. This is the responsibility of the learners.

It is disturbing that Bridget had such negative attitude towards continued learning because the Framework for K-12 Science Education and Next Generation Science Standards (NGSS) (2013) indicate that all teachers need to acquire new knowledge and skills regardless of their qualification and experience. Bridget was the only one without a degree qualification as she only had a diploma qualification, which then explains her poor content knowledge of the concepts on meiosis.

There is however a discrepancy between John's levels of content knowledge, considering that he had a degree in Biology education and at the same time he was the youngest, meaning that he could have covered those concepts at both high school and university modules. This confirms Ball, Thames and Phelps (2008)'s justification of the need for teachers' continued learning of content since content knowledge for teaching is different from the content knowledge acquired during university learning. Sarah had the highest score, which could be explained by her higher qualification (BEd honours degree), continued exposure to the content on meiosis, as she had the longest teaching experience (28 years) and particularly 11 years in teaching Grade 12 content.

5.2. Teachers' experiences in teaching meiosis to grade 12 learners

Sarah's lesson plans were the most comprehensive compared to other teachers' lesson plans with details of expected learning outcomes, how she would introduce the concepts, how she would develop the lesson to ensure learner acquisition of the content and inclusion of assessment activities to check for learner understanding of meiosis. During lesson observations, Sarah used guided instruction (Magnusson, Kracijk & Borko, 1999). Sometimes she used a video to introduce the concepts on meiosis, and then asked probing questions, which stimulated learners' interest. Sarah explained the concepts whilst involving learners in group activities, which engaged learners throughout the lessons. When asked why she taught in that way, Sarah justified her active involvement of learners when she said, "When learners become actively involved in their own learning, they experience science in a different, interesting and enjoyable way; they will be able to think critically, solve problems and be able to work with other learners". She also justified her frequent use of questions as a way of assessing learners' understanding throughout the learning process. Her teaching was learner-centred.

John's lesson plans had the basic required components such as the aims and objectives, which guided the scope of the content of his lessons. John followed the sequence of the content as given in the learners' textbook. In one of the lessons for instance, John introduced the lesson by showing learners a picture of a child with Down Syndrome. He then asked, "Which abnormality is this?" Instead of building up his lesson on this, John just explained concepts on meiosis such as karyogram, chromatin, chromatid, karyotype, reduction division, without making proper reference to his introduction. John justified his excessive use of learners' textbook as the only source of content, examples and activities when he said, "It is easy for the learners to follow the textbook while they study at home by themselves". The main characteristic of John's teaching was teacher-centredness; but, he sometimes allowed his learners to share their ideas and frequently asked topic related questions. His engagement with learners took the form of a simplistic dialogue based on interaction-response-feedback. Though John had taught Life Sciences for seven years, he had taught Grade 12 content for only three years, which made him teach like a novice.

Bridget's lesson plans were sketchy. When observed teaching, Bridget did not engage learners, other than giving them page numbers to read from the textbook without any guidance. She also tasked them to write an activity in that same textbook soon after reading. Bridget justified her teaching strategy when she said, "It is not my responsibility as a teacher to know the content, learners are supposed to read and know the content while the teacher is only responsible for 10%, which is to check if learners are doing well". Bridget did not guide learners on what to look for when reading or interpret the instructions and questions, and even brainstorm on the activities with the learners before assigning learners some work. The main characteristic of Bridget's teaching was largely textbook-centred. Learners were left to do everything by themselves without the guidance of the teacher.

5.3. The relationship between teachers' knowledge of meiosis and their teaching practices

In this section, the teachers' Topic Specific Pedagogical Content Knowledge (TSPCK) is assessed, which Mavhunga and Rollnick (2013) denoted as responsible for teachers to pay particular attention to certain aspects of the content of the topic (meiosis) in relation to what learners already know and with respect to topic structure. The focus is specifically on how the teachers structured the content and their knowledge of learners' difficulties in learning meiosis, and the teachers' identification and use of appropriate teaching strategies for specific concepts within the topic meiosis. The three teachers had taught in these schools for a number of years, as a result, they were considered to be knowledgeable about their teaching context, which informed their teaching. For instance, Bridget pointed out that her learners came from poor socio-economic background and had problems in understanding and communicating in English, which is their second language. Unfortunately, her teaching did not take into consideration those learners' difficulties.

From the interview responses and lesson observations it depicts that Bridget had poorly developed PCK to teach meiosis. This is also evidenced by her low score in the test on concepts on meiosis. This is confirmed by Lee (1995) who pointed out that because of poor subject matter knowledge, a science teacher relies solely on the textbook as a teaching tool and avoids class discussions which could give learners autonomy to explore further and ask questions.

Unlike Bridget who failed to identify specific concepts under meiosis that her learners had difficulty in, John and Sarah identified crossing over and random segregation; and differentiating meiosis 1 from 11. According to John, these concepts are very abstract and unfamiliar to the learners. Based on his low test score (56%) and his limited experience (3 years) in teaching the topic, John's presentation of lessons was mostly teacher-centred. This confirms his poor TSPCK because in a study to determine South African physical sciences teachers' perceptions of new content in a revised curriculum, Ramnarain and Fortus found that the teachers who had difficulty in conceptualising the new topics shifted their pedagogy towards more teacher-centred approaches which provided them with more authority and autonomy in managing learning.

Sarah displayed well developed PCK when planning, teaching and assessing learners' understanding of the concepts of meiosis. She was knowledgeable about the concepts on meiosis.; she was very versatile in responding to learners' difficulties; and used various teaching strategies that engaged learners.

6. Discussion

From the findings, it shows that out of the three teachers, only one teacher possessed adequate content knowledge level to teach concepts on meiosis. One teacher showed a negative attitude towards continued learning. Bridget's teaching was textbook-centred and John's one was teacher-centred. Though classroom teaching experience is an important factor in enhancing teachers' PCK (Drechsler & Van Driel, 2008), the findings showed that experience alone is not adequate for effective teaching because the two most experienced teachers, Bridget and Sarah, taught differently and showed a wide range of variation in PCK development. This can be explained by previous researchers who in relating subject matter knowledge to classroom practices indicated that subject matter knowledge is considered as a prerequisite to and the main source of PCK (Lemberger, Hewson & Park, 1999). Bridget had limited knowledge of the concepts on meiosis, which made it difficult for her to explain it clearly to her learners.

7. Conclusions

The study investigated Life Sciences teachers' preparedness and experiences in teaching the topic meiosis to Grade 12 learners. The findings showed that only one teacher had adequate knowledge about meiosis. The other two teachers showed lack of knowledge on the concepts of meiosis. As a result, their teaching was compromised in that one teacher relied heavily on the textbook and the other teacher used teacher-centred methods, which denied learners an opportunity to engage in the teaching and learning process. We conclude that teachers' confidence in knowledge of the concepts to be taught determines how they teach the learners. The confidence comes from teachers' preparedness in terms of subject matter knowledge and pedagogical skills. The study contributes significant information to the field of Life Sciences education in that the level of teacher qualification to teach a subject should be taken seriously. In-service teacher professional development programmes are inevitable.

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