

# How spiral is the South African Physical Science curriculum? A case study of Electrolytic Cells in Grades 10–12

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## ABSTRACT

The South African Physical Science curriculum is regarded as spiral in nature due to its progression of concepts across grades, and its coherence of ideas within grades. A spiral curriculum supports coherence and boosts learner achievement in science. This inquiry examines the fundamental principles of electrolytic cells in the knowledge area of chemical change at the secondary level (Grades 10 to 12). Electrolytic cells' spiral nature was determined by analysing the Physical Science Curriculum (PSC) and 2019 Physical Science Work Schedule (PSWS), using pedagogical link-making for continuity. The PSC passed the spiral test due to the presence of increasingly difficult concepts across grades. Due to the absence of fundamental concepts like oxidation numbers and electrolytes in Grades 10 and 11, the PSC failed the conceptual progression test. Furthermore, the spiral characteristics of the PSC were compromised in the 2019 PSWS document. The sequencing of concepts in the 2019 PSWS does not encourage linking on the meso scale, where the interlinking of ideas is vital for learner comprehension and conceptual understanding. Curriculum designers should introduce oxidation numbers in Grade 10 and electrolytic cells in Grade 11. Furthermore, it is recommended that curriculum designers consider separating chemistry and physics knowledge areas.

## KEYWORDS

electrolytic cells; spiral curriculum; pedagogical link-making; promoting continuity; scientific story

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## INTRODUCTION

The sequencing of Physical Science topics in the South African Physical Science Curriculum (PSC) has been in question since its inception in 2011. In this article, the Physical Science Curriculum Assessment Policy Statement (CAPS) is referred to as the Physical Science Curriculum (PSC). The PSC categorises its topics in terms of knowledge area, and each topic under the knowledge area is assigned the number of hours during which it should be covered in class. The 2019 Physical Science Work Schedule (PSWS) is a working document that teachers are supposed to use in their daily lesson planning. It dictates the topics and concepts to be taught in a term, week, or for a certain duration. The 2019 PSWS further sequences the concepts according to how they should be taught. This study examined the two common documents, the 2019 Gauteng PSWC and the PSC.

The Department of Basic Education (DBE) claims that the curriculum is structured in a spiral manner. The concepts are progressive across grades and coherent within grades.<sup>1</sup> An analysis done by Umalusi suggests that the curriculum is largely progressive across the grades, but not coherent within grades.<sup>2</sup> In contrast, Sibanda and Hobden<sup>3</sup> find no progression within topics across the grade. It should be noted that the report by Umalusi compared the structure and coherence of the PSC against the curriculum in the previous National Curriculum Statement (NCS) across all topics within the science content document.<sup>1</sup>

Sibanda and Hobden have found significant differences between teachers' sequencing of chemistry topics and the PSC's prescribed approach in Grades 10 to 12.<sup>3</sup> While the PSC suggests that the sequencing of topics in chemical bonding start with concepts at the macroscopic level, some teachers prefer to order their lessons starting with concepts at the sub-microscopic level.<sup>4</sup> Furthermore, teachers feel overly restricted in implementing the work schedule in its prescribed format.<sup>4</sup>

For learners to have sound conceptual knowledge of the curriculum and do well in assessments, the order of topics within the curriculum and the conceptual coherence of topics are critical. Students can learn

science meaningfully if the science curriculum is sequenced according to a spiral structure.<sup>5</sup> It is further suggested that an integrated spiral curriculum accomplishes the primary purpose of giving pupils high-quality learning experiences through consolidating information, fostering a thorough understanding of concepts, and solidifying knowledge over time rather than just at the time of assessment.<sup>6</sup> Hypothetically, if Umalusi is correct in saying that the PCS is progressive, this article poses the question: why is electrolysis one of the subjects in which students have consistently fared poorly in their final exams? It has been shown that an adequately executed spiral curriculum frequently leads to improved student performance.<sup>7</sup>

This study aimed to examine the degree to which the topic of electrolytic cells and its underlying concepts conform to a spiral curriculum within and across grades at the secondary school level (Grades 10 to 12). This was done utilising a framework that measures the spiral nature of the curriculum, and tests the connections' meaningfulness. The following questions guided the direction of the investigation:

1. To what extent does the PSC show a progression from Grade 10 to Grade 12 at secondary school level?
2. Does the sequencing of electrolytic cells and its underlying concepts follow a coherent structure that fosters conceptual understanding in each grade?

## BACKGROUND

The knowledge area of chemical change in chemistry is a challenging knowledge area in South Africa. In a study of the performance of first-year chemistry students at the University of Cape Town, it was found that students did poorly in reactions and stoichiometry.<sup>8</sup> It was shown that these students' comprehension of fundamental scientific concepts, such as atoms and ions, the mole concept, chemical reactions, acids and bases, chemical solutions, and stoichiometry, had declined significantly from what they were taught in Grade 12 the previous year.<sup>8,9</sup> Further research highlights that Grade 12 learners may have several alternative conceptions of electrochemistry; however, it has been shown that learners do not comprehend the concepts around electrolysis compared to how they understand galvanic cells.<sup>10–11</sup> These topics fall under chemical change in the PSC from Grades 10 to 12.

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