ADDRESSING CONTENT KNOWLEDGE GAPS, DIDACTICS AND PEDAGOGY TO IMPROVE TEACHER EFFECTIVENESS IN LIFE SCIENCES IN DINALEDI SCHOOLS: A CASE STUDY

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ABSTRACT - The purpose of this study is to examine the impact of a support and guidance professional development intervention programme in addressing content knowledge gaps, didactics and pedagogy to improve teacher effectiveness in selected Life Science topics in Dinaledi Schools in South Africa. The study is guided by the conceptual change theoretical framework. A case study research design which utilised a one group pre-test post-test quasi-experimental research design, without a control group, was employed. The sample consisted of 51 Grade 12 Life Science teachers at Dinaledi schools drawn from the North-West province of South Africa. Data was collected using pre- and post-tests before-and-after the intervention programme and analysed this data using Muchtar's (2012) framework and non-parametric inferential statistics. The results indicate that teachers have difficulties in certain concepts, namely; genetics and inheritance, human evolution, the Out of Africa hypothesis and protein synthesis. Teachers also acknowledge that conceptualising a topic from the 'big ideas' perspectives enables them to teach it effectively. The significance of this study rests in recommending more of such interventions throughout the year for teachers to improve their content knowledge and Science pedagogy as evidenced by analysis of their summative evaluation of the intervention.

Keywords: Life Science concepts, Life Science Dinaledi teachers, conceptual change, professional development, intervention.

1. INTRODUCTION

Education in South Africa (SA) is under pressure because, despite the huge financial investment, it does not produce good results and this makes for critical headlines in both print and electronic media (Petersen & De Beer, 2012). After years of poor comparative performance in education rankings, South Africa finally achieved its lowest ranking in an international measure of the quality of Mathematics and Science education (Gernetzky, 2012). It is not the purpose of this article to focus on the shortcomings in the education sector, but report a case study investigation that describes the nature and scope of a professional teacher development (PTD) programme, that could contribute to improving the situation as well as recommend suggestions.

Facilitation to support and guide teachers in developing their content knowledge, didactics and pedagogy for the benefit of learners has grown in significance over the past two decades in South Africa. Facilitation is countenanced as a process where professional development support is delivered to classroom teachers and focuses on particular subject matter, content or pedagogical approaches intended to build their instructional skills and abilities (Yost, Vogel & Rosenberg, 2009). However, questions remain unanswered as to how facilitation is pragmatically implemented and achieved in practice as it takes different forms (Waterman, Boaden, Burey, Howells, Harvey, Humphreys, Rothwell and Spence, 2015). Moreover, little evidence exists on what it is that researchers do to support the implementation process (Waterman et al, 2015). Pretorius, De Beer and Lautenbach (2014) lament that professional development interventions in South Africa do not always address teachers' needs or necessarily result in better realisation of outcomes in science. Pretorius et al. (2014) further argue that South African teachers' learning of science and their nascent science pedagogy need urgent attention and that this issue can be addressed through focused professional teacher development (PTD) programmes. This notion gives credence to the undertaking of this study given that South African teachers' science content and their pedagogical inadequacies could be addressed through focused PTD programmes. This is attested to by prior studies where teachers changed their instructional practices and gained greater subject knowledge and improved teaching skills when their professional development was directly linked to their daily experiences, as well as aligned with benchmarked standards in assessment (Holland, 2005; Pitsoe & Maila, 2012).

1.1 Background to the study

In order to fully understand the background in which this study was undertaken, a description of the context is proffered. Generally, the number of learners passing matriculation examinations in South Africa has been increasing. For example, Matsemela (2015), noted that for the North West province, since 2008, there has been a steady increase in the pass rate evident in the following statistics: 2008 (68.0%), 2009 (67.5%), 2010 (75.7%), 2011 (77,8%), 2012 (79.5%), 2013 (87,2%), 2014 (84.6%) and a slight decrease in 2015 (76.5%). Despite this steady increase in the pass rate, the major concern has been the quality of the passes in Mathematics and Science subjects. As noted by the Gauteng Department of Education (2010), the achievement of a sustained and significant improvement in Mathematics, Science and Technology (MST) teaching and learning throughout the public school system in South Africa continues to be an elusive goal. A significant amount of funding, effort and time has been invested in order to raise the quality of MST education over the past 16 years, yet the problem has been persistent (Gauteng Department of Education, 2010). According to Kriek and Grayson (2009), the impediments to success and the reasons for the poor pace of progress are complex and only vaguely understood. These include: poverty, lack of resources, entrenched poor learning cultures, poor infrastructure of schools and low teacher qualifications as well as inappropriate regional distribution of Mathematics and Science teachers. To overcome impediments such as those cited in the preceding segment, the Integrated Strategic Planning Framework for Teacher Education and Development in South Africa (2011–2025) Technical Report (2011) states that teacher development support structures and functions need to be improved and better coordinated, among the national, provincial, district and school levels, and also involve higher education institutions.

In an attempt to address some of these impediments related to pedagogical factors, the Department of Education's (DoE) Mathematics, Science and Technology Services (MSTS) North-West province, which is part of the General and Further Education Training Services, holds professional development intervention programmes in the first quarter of each year in Mathematics and Science subjects. PD involves teacher training and learning. From a situative perspective, teacher learning "is usefully understood as a process of increasing participation in the practice of teaching, and through this participation, a process of becoming knowledgeable in and about teaching" (Adler & Reed, 2002, p. 37). The intervention described in this paper is only for Life Science teachers at Dinaledi schools and specifically related to content knowledge, didactics and pedagogy.

Life Science is one of the subjects where the intervention programme was implemented. The 2014 NSC examination represents the first year that the new Curriculum and Assessment Statement (CAPS) syllabus was assessed at Grade 12 level. While many subjects have not experienced dramatic content changes from the previous curriculum (the National Curriculum Statement - NCS), a number of subjects have undergone significant changes and shifts in format (Volmink, 2015 cited by Matsemela, 2015). For Life Science, the format and structure of the subject was not affected by CAPS in any significant way. However, according to Umalusi Council (the Quality Assurance Body of examinations in South Africa), there were fairly major changes in the depth of content, cognitive demands and the curriculum spread for Life Science as a subject. Umalusi is also tasked with quality assurance of the new CAPS curriculum and making recommendations to the Minister of Basic Education where necessary. The MSTS North-West province sensed there was need to run an intervention with Life Science teachers at Dinaledi schools to address the content knowledge gaps, didactics and pedagogy which they perceived could be problematic as these stemmed from in-depth changes of the Life Science content, cognitive demands and the curriculum extent for Life Science as a subject. All this was aimed at improving teacher effectiveness in Life Sciences in Dinaledi Schools.

1.2 Why Dinaledi teachers?

A question is posed, why Dinaledi teachers? In 2001, the SA Cabinet adopted the National Strategy for Mathematics, Science and Technology Education (NMSTE) (Department of Education [DoE], 2009). In response to this national strategy, the Department of Education established the Dinaledi School Project in the same year to increase the number of matriculants with university-entrance mathematics and science passes (DoE, 2009). Other goals of the national strategy included setting performance targets in all schools and ensuring that qualified and competent teachers were available in every classroom. The Dinaledi schools fall under the Dinaledi programme which supports selected schools with a view to significantly increase the participation and performance of learners, especially African and girl learners, in Mathematics, Life sciences and Physical sciences (The Departments of Basic Education and Higher Education and Training, 2011). Since its inception in 2002, the Dinaledi programme has expanded from 102 to 500 schools across all nine provinces of South Africa (Gauteng Department of Education, 2010). Dinaledi schools receive additional learning resources and teachers who are equipped with appropriate pedagogical and content skills, and languages of instruction. For inclusion in the Dinaledi programme, secondary schools were selected on the basis of having achieved at least 35% Senior Certificate Mathematics pass by African learners. Some former Model C schools that met these criteria were also included in the Dinaledi project (Gauteng Department of Education, 2010). Former Model C schools used to have the best resources and teachers under apartheid and some of these schools currently still enjoy these privileges.

The selection of Dinaledi schools is the provenance of provincial education departments in collaboration with the national department in terms of the constitutional allocation of powers (DoE, 2009). This has led to some unevenness in the implementation of the Dinaledi project, with procedures for adding or excluding schools not being applied uniformly across provinces. Contrary to expectations, the Dinaledi school programme has achieved some of its goals, but not at the positive level that was intended (Van Wyk, 2013). A ministerial task team recently appointed by the Basic Education minister to investigate the problems regarding mathematics, science and technology subjects in schools, found that poorly qualified teachers are the main problem in schools, and universities are to blame for not providing teachers with adequate pedagogical training (Van Wyk, 2013). Despite their Dinaledi status, similar problems are bedevilling some Dinaledi schools. Some of the Dinaledi schools are under-performing schools. In this paper, the term “underperforming" is used to describe those schools where all appear, at least superficially, to be reasonably well resourced and well managed yet the performance of their learners in externally benchmarked tests has, in most instances, been abysmal. Underperforming schools are those schools that achieve an average pass rate of less than 50% in the National Senior Certificate, specifically in Life Science in this study.

2. Research Questions

The purpose of the study was to ascertain the impact of a PD intervention on Dinaledi Schools Life Science teachers’ conceptual change. Focus of the PD intervention was to assist teachers in addressing content knowledge gaps, didactics and pedagogy to improve teacher effectiveness. It was hoped that by the end of the intervention, teacher competencies would entail improved content knowledge, pedagogy and enhanced teacher practices. To achieve this purpose, two questions provided focus for this study. These are:

To what extent did the professional development intervention address content knowledge gaps, didactics and pedagogy to improve teacher effectiveness?

What are the implications of this research for classroom practice and Science curriculum development?

3. Theoretical Framework

The theoretical framework guiding this study draws on the Conceptual Change Model (CCM) proposed by Posner, Strike, Hewson and Gertzog (1982). The CCM is the mechanism underlying meaningful learning. The *conceptual change* theoretical framework guiding this study focuses on knowledge acquisition in specific domains and describes learning as a process that requires significant reorganisation of existing knowledge structures and not just their enrichment (Vosniadou & Brewer, 1987). The processes of knowledge acquisition and development can proceed either in the direction of enriching existing knowledge structures or towards restructuring them (Vosniadou & Brewer, 1987). Theory-like knowledge structures allow developmental change and this is exactly what conceptual change is meant to be. The *conceptual change* is important if we are to understand the process of learning and is vital when designing an instructional sequence for continuing professional development.

The conceptual framework related to this theory and also guiding this study is based on literature on the operationalisation of *misconceptions*. Over the past few decades, considerable research has been conducted on student conceptions and alternative conceptions for a variety of aspects of Life Sciences also called Biology, for example, misconceptions in genetics (Mbajiorgu, Ezechi, & Idoko, 2007), misconceptions in protein synthesis (Fisher, 1985), misconceptions in the Out of Africa hypothesis (Ankel-Simons& Cummins, 2000), and misconceptions in evolution (Journeys, 2010). Students' self-constructed conceptions have been referred to in the literature as alternative conceptions, misconceptions, preconceptions, naive conceptions, children's Science, intuitive beliefs, alternative frameworks, students' errors, and non-scientific ideas (Hamza & Wickman, 2008). These mental representations of concepts − which are at variance with currently-held scientific theory − are distinguished into two kinds: (a) Alternative or experiential or intuitive or native conceptions and (b) instructional misconceptions (Nakiboglu, 2003). Throughout this article, the phrase *misconceptions* has been used to refer to these ideas that are not in consonance with accepted scientific ideas. Students at all levels, and even Science teachers, hold *misconceptions*: conceptual and propositional knowledge that is inconsistent with or different from the scientific consensus and is unable to adequately explain observable scientific phenomena. Misconceptions are very resistant to change, persistent, and difficult to erase even with instruction specifically designed to address them. One way of addressing misconceptions is through conflict teaching. A concise description of the structure of what actually constitutes conflict teaching is the initial activity, discussion and consolidation. As a result, the study was designed to address content knowledge gaps, didactics and pedagogy to improve teacher effectiveness while concurrently identifying previously reported and new alternative frameworks of practising teachers in the recently introduced Life Science CAPS curriculum, taking into account the uninvestigated concepts of the newly introduced topics.

Professional development is the other phrase which needs operationalisation. Designers of PD can be guided by the extensive body of research on how effective change occurs in educational settings. According to Kriek and Grayson (2009), current research into the effective professional development of teachers indicates that this is nothing new but, in recent years, the way in which it is structured and delivered needs to be reconceptualised. Many scholars still assert the need for new approaches to professional learning that are responsive to the needs of both schools and teachers. Kriek and Grayson (2009) further note the fact that traditional "one-shot" approaches to PD are inadequate and inappropriate in the context of current educational reform efforts. PD of teachers is therefore seen as intellectually superficial, disconnected from deep issues of curriculum and learning, fragmented and non-cumulative. PD that is of longer duration is more likely to contain the kinds of learning opportunities necessary for teachers to integrate new knowledge into practice.

4. Methodology

A case study research design which utilised a one group pre-test post-test quasi-experimental research design, without a control group, in order to establish if the professional development programme addressed content knowledge gaps, didactics and pedagogy of teachers to improve their teacher effectiveness was used. The effectiveness of the intervention was assessed by comparing the initial and final scores obtained by the practicing teachers in the concept test through the Wilcoxon Signed Rank Test.

4.1Sample

Participants. The sample consisted of 51 Life Science Grade 12 teachers (21 males and 30 females) who teach at Further Education and Training (FET) band, that is, Grades 10-12. The sample was purposively selected from the North-West province of South Africa. Purposive sampling is a non-probability sampling method whereby only those people a researcher thinks could provide the relevant information are selected. The teachers all came from 51 Dinaledi schools. Each school seconded one teacher for the workshops. North-West province has about 300 high schools and of these 51 are Dinaledi schools which get a Dinaledi grant from the National Treasury. The Department of Education, North-West province subpoenaed all Grade 12 Life Science teachers from Dinaledi schools to attend. All the 51 teachers were black with varied teaching experience ranging from eight to thirty years. Forty-four of the teachers were Setswana speaking, five were Shona speaking and two were Indians. The teachers held a variety of qualifications with the minimum qualification being a Bachelor's degree and the highest qualified were four teachers holding postgraduate degrees which is a Master's degree in their areas of specialisation.

Researchers. The professional development providers included 2 male Science educators specialising in Life Sciences from a large research university. Both Science educators had a PhD in Science education and had taught genetics, human evolution, cell biology and introductory laboratory courses at both high school and tertiary level. One of the Science educators had 12 years' teaching experience whilst the other had 23 years. They were both working at one of the three campuses of the participating university.

4.2 Research Methods

Six months prior to the professional development intervention programme, an agreement was made between the North West province's Mathematics, Science and Technology Services (MSTS) sub-directorate managing and coordinating the Dinaledi project and the participating university. The university was to provide two experienced Science educators who would develop Grade 12 Life Science training materials for 51 teachers for the selected topics (which had been derived from the analytical moderation of assessment in Grade 12 and the CAPS Grades 10-12 requirements). The topics comprised genetics and inheritance, human evolution (including the Out of Africa Hypothesis and alternatives to evolution) and protein synthesis. The two Science educators would then go on to train the 51 Life Sciences teachers for a week after 6 months.

The participants were first given a concept pretest which consisted of 15 standard four-alternative multiple-choice questions, where three alternatives are wrong, and only one is correct and 5 open-ended questions. These questions were adapted from Department of Basic Education's (DBE) past examination and exemplar papers. According to Bontis, Hardie and Serenko (2009), factors irrelevant to the assessed material (such as handwriting and clarity of presentation) do not come into play in a multiple-choice assessment, and so the candidates are graded purely on their knowledge of the topic. Such questions became essential given the aim of the study and also that arrange of concepts were to be assessed. An example of a multiple choice question in the concept pre-test is as follows:

If blue eye colour (b) is recessive to brown eyes (B), what would be the genotype of a brown eyed person?	
A. bb or BB	B. Bb or BB

Figure 1: Example of multiple-choice question

The five open-ended questions were also adapted from DBE past examination questions. An example of the structure of the questions is as follows:

❖ Professor Lee Berger and his colleagues studied the fossils they found in a cave at the Cradle of Humankind. The skeletons from the cave are ranked amongst the most complete finds to date. The adult female, *Australopithecus sediba*, was remarkably well preserved and some of the following characteristics were identified:

Some characteristics of *Australopithecus sediba*:

- A small brain size
- Bipedal
- Smaller canines
- Projecting nose
- Small body size

[Adapted from 'Part Ape Part Human', Josh Fischmann, *National Geographic*, August 2011]

➢ Write down THREE characteristics from the list above that also apply to the *Homo* species.

➢ State TWO advantages of *A. sediba* being bipedal.

Figure 2: Example of open-ended question

Despite the questions having been adapted from previously validated examinations, content, criterion and face validity of the instrument had to be ascertained and this was determined by considering the experts' ideas in the Educational Sciences Faculty of North West University and the Biology Department of North West University. The reliability of the test was determined as 0.92. The concept test was also taken to the MSTS together with developed training material for further validation and to see if materials met the standard as expected by the North West Department of Education's professional development intervention goals. Non-parametric inferential statistics was used to analyse multiple choice subject scores. Qualitative content analysis (Creswell, 2009) was used to analyse qualitative data. Firstly, two Science educators independently analysed written open-responses of in-service Science teachers, then they came together and discussed the answers to reach consensus. The same test was given as the post-test after the intervention to check for conceptual change. The post-test was administered after a week of intervention. The participants were then divided into 2 groups one containing 25 and the other 26 participants. This was done by the Department of Education officials. The stratified random sampling technique (Gall, Borg & Gall, 2007) was used. The officials wanted to ensure that the groups were representative of schools from different districts of the province.

A timetable was drawn up, ensuring that participants had equal time with each of the two facilitators. One facilitator handled genetics and inheritance as well as introductory concepts of human evolution topics. The other facilitator focused on the *Out of Africa Hypothesis* and protein synthesis topics. Sessions commenced at eight o'clock in the morning and ended at five o'clock in the afternoon. Effectively, sessions ran for 7 hours, excluding lunch and tea breaks. The data was collected through hybrid methods of cognitive coaching (which is based on the idea of the construction of knowledge), conflict teaching and traditional approaches (the transfer of knowledge). The didactics was dealt with from the Big Ideas concept. A *big idea* refers to the science ideas that the teacher(s) see as crucial for learners to develop an understanding of a particular topic (Loughran, Berry & Mulhall, 2006). Teachers were asked to construct a CoRe- Content Representation for each topic. Furthermore, each teacher was asked to identify at least five big ideas for each topic, e.g. evolution. Then the teachers were asked to complete eight prompts for each big idea. Examples of prompts include: What do you intend learners to learn about this idea?; Why is it important for learners to know this?; What else do you know about this idea (that you do not intend students to know yet); Difficulties/limitations connected with teaching this idea; Knowledge about students' thinking which influences your teaching of this; Other factors that influence your teaching of this idea; Teaching procedures (and particular reasons for using these to engage with this idea. Finally the teachers were made to make a concept map for each topic and discussions were held based on each participant's work. The current CAPS document expects teachers to be knowledgeable regarding content and pedagogy (PCK) of these concepts which were covered in the intervention.

4.3 Data Analysis

Both the pre-test and the post-test participants' responses were marked against a memorandum (ideas that are in agreement with accepted scientific ideas). It has to be noted that the aim of the study was not to ascertain misconceptions. However, misconceptions were identified for various Life Science topics and aspects. This was done so as to address content knowledge gaps evident in the practising teachers. Grouping of participants' responses was conducted by analysing the quality of the responses and categorising them following criteria used by Muchtar (2012). A colleague (a Science educator at the same university) also independently analysed and categorised the quality of the participants' responses for two aspects namely; the dihybrid crosses and Out of Africa Hypothesis. There was agreement in the analysis and categorisation which signified reliability. In this paper, there were four diagnosed categories of misconceptions, which were all presupposed categories. Following inter-reliability checks, participants' responses were then classified into four categories based on the following criteria by Muchtar (2012):

Scientifically Correct (SC): This group consists of scientifically complete responses and correct explanations

Partially Correct (PC): Any scientifically correct responses but incomplete explanations fit into this category

Specific Alternative Frameworks (SAF): Any scientifically unacceptable responses or explanations are included in this category-naive Life Science.

No Understanding (NU): Groups who do not give any response; give irrelevant or unclear explanations; just rewrite the question or no explanations are put into this category.

As mentioned earlier, the terms 'alternative frameworks' and 'misconceptions' have the same meaning and can be used to refer to participants' conceptions that are different from scientifically accepted ones (Taber & Tan, 2011). The misconceptions were then compared with those in literature; misconceptions in genetics (Mbajiorgu, Ezechi, and Idoko, 2007), misconceptions in protein synthesis (Fisher, 1985), misconceptions in the Out of Africa hypothesis (Ankel-Simons & Cummins, 2000), and misconceptions in evolution (Journeys, 2010). A Wilcoxon Signed Rank Test was conducted to determine if there was a change in the scores on the concept test from the pre-test to post-test.

5. Results and Discussion

Grouping of participants' responses (based on their understanding) was conducted by dividing the responses into four different groups described in the data analysis section. Based on the data analysed from participants' responses to all questions, most of the responses fitted into the scientifically correct (SC) category. The participants held conceptual and propositional knowledge that is consistent with or not different from the scientific consensus. No responses from the participants fitted into the 'no understanding (NU)' category. Participants' responses in three Life Science aspects fitted into specific misconceptions and partially correct (PC) categories. These are:

genetics and inheritance

introductory concepts of human evolution topics

protein synthesis topics and Out of Africa hypothesis

5.1 Genetics and inheritance

From the pre-test, the common misconceptions which were exhibited by the teachers include: genes determine all traits, all mutations are harmful, dominant traits are the most common traits in a population or alleles are found in abundance, a gene for every trait, once a mutation has been discovered, it can be fixed, only genetically modified food crops have genes; and if a couple has "one-in-four" risk of having a child with a disease, and their firstborn has the disease, the next three children will have a reduced risk. These misconceptions are not new. The findings of the current study are consistent with those of Shaw et al. (2008) who found similar misconceptions with high school students in genetics content. This finding is in agreement with Mbajiorgu, et al.'s (2007) findings who also found similar misconceptions. As noted earlier, the purpose of the study was not to identify misconceptions. Having identified these misconceptions, the intervention then used cognitive coaching to address the misconceptions. As described by Charner-Laird (2007), teachers explore the thinking behind their practices during cognitive coaching. Each person seems to maintain a cognitive map, only partially conscious. Questions were asked by the coaches, in this case, the two science educators, revealing to the teacher areas of that map that may not be complete or consciously developed. Teachers were then given the platform to talk out aloud about their thinking, their decisions becoming clearer to them, and their awareness increasing.

5.2 Introductory concepts of human evolution topics

The pre-test elicited that the teachers held the following five misconceptions regarding introductory concepts of human evolution topics, namely, (1) evolution only occurs slowly and gradually, (2) humans are not currently evolving, (3) natural selection gives organisms what they need, (4) evolutionary theory implies that life evolved (and continues to evolve) randomly, or by chance, and (5) the fittest organisms in a population are those that are strongest, healthiest, fastest, and/or largest. These results are consistent with those of other studies (Journeys, 2010; Yates & Marek, 2015) and suggest that teachers, just like learners, also hold misconceptions in human evolution topics. After identifying the misconceptions and the teachers having been made to realise the misconceptions they hold on this topic, conflict teaching was used to address the misconceptions.

5.3 Protein synthesis topics and *Out of Africa Hypothesis*

Some teachers have the mistaken notion that amino acids are produced by translation. Though enzymes catalyse steps in protein synthesis, they are also the products of protein synthesis. This also concurs with Fisher's (1985) observations, which showed that Biology students had similar misconceptions regarding this topic. The two science educators recognised that teachers may not have understood the source of amino acids that are used in translation, and had to address this topic directly. Science educators addressed teacher confusion about the products of translation in the intervention lessons on protein synthesis. The pre-test also showed that teachers had specific misconceptions regarding the Out of Africa hypothesis. The misconception pertained to the evolutionary biology's belief in the clonality of mitochondria on the perpetuation of a myth, that paternal mitochondria do not enter the egg. Studies by Ankel-Simons and Cummins (1996) have demonstrated the contrary despite several textbooks and papers having stated that the mid-piece and tail of the sperm, containing all the paternal mitochondria, fall outside the egg. There has been, and continues to be, overwhelming evidence that this is not so. However, this result has not previously been described or found as held by teachers or students. To address this misconception, the two strategies (conflict teaching and cognitive coaching) were utilised as explained earlier to address the other misconceptions.

5.5 Big ideas approach

The big idea approach was the most interesting part of the PD programme. Participants conceptualised these topics differently. Most of the participants had different big ideas with a few participants having similar ideas. The concept maps were also different. However, the teachers appreciated having gone through the exercise as they had a clear idea on how they were going to proceed with teaching the topics. One teacher in the evaluations wrote: “I can now link the concepts as I teach these topics. It is no longer a case of just getting a textbook and checking the schedules when I go to teach in class. This has taught me to properly prepare. The big ideas and the prompts were an eye-opener.” The teachers acknowledged that using the big idea approach was beneficial to both themselves and the learners in their evaluations. Emphasis was that a big idea is an explanation of an observed phenomenon and needs to be explained.

5.6 Statistical results

Inferential statistics results are presented in Tables 1, 2 and 3.

Table 1. Paired samples statistics

Table 2. Paired samples test

Table 3. Wilcoxon Signed Rank Test

	Post-test- Pre-test
Z Asymp. Sig. (2-tailed)	-9.330[a]

	Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1 Pre-test	36.56	51	10.24	.90
Post-test	77.57	51	14.01	.90

	Paired differences							
	Mean	Std. Deviation	Std. Error Mean	95% Confidence interval of the Difference				
				Lower	Upper	t	df	Sig. (2-tailed)
Pair 1 Post-test - Pre- test	2.28	34.35	.47	1.64	3.66	16.49	50	0.000

[a]Based on positive ranks.

Pre- and post-test results were found as follows: A paired-samples t-test was conducted to evaluate the impact of the intervention on participant’s scores on the taxonomy of misconceptions in genetics and inheritance, introductory concepts of human evolution topics, protein synthesis topics and Out of Africa hypothesis concept test. There was a statistically significant increase in concept test scores from the pre-test (M=36.56, SD=10.24) to the post-test [M=77.57, SD=14.01, t (50) =16.49, p<.0005]. The eta squared statistic (.50) indicated a large effect size. We can conclude that there was a large effect, with a substantial difference in the concept test scores obtained before and after the intervention. A Wilcoxon Signed Rank Test was conducted to determine if there was a change in the scores on the concept test from the pre-test to post-test. Teachers' two sets of scores (pre-test and post-test) were found to be significantly different as determined by the Wilcoxon Signed Rank Test (Z = -9.33, p = 0.00).

6. Conclusions and Recommendations

From the results presented and discussed, the professional development intervention addressed content knowledge gaps, didactics and pedagogy to improve teacher effectiveness to a larger extent. After teachers' misconceptions were identified, teaching strategies were used to address the teachers' content knowledge regarding specific topics dealt with by the intervention. Regarding didactics and pedagogy, the Big Idea strategy was well received by the teachers as they were given an opportunity to construct their own Content Representation (CoRe) for planning and teaching. The statistical results show that there was significant increase in concept test scores. However, given the short time between pre- and post-testing, there might have been contamination of results which is a limitation of the study. The study recommends that teachers who receive such instruction should be encouraged to train other teachers in their immediate area, perhaps by establishing local communities of practice groups. These would complement existing or future government schemes. The study recommends a deviation from the once-off professional development and suggests approaches to professional development that are robust appropriate in the context of current educational reform efforts in South Africa. Further research should be done to establish how the teachers are teaching after having participated in the intervention.

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