EFFECTIVENESS OF RECONCEPTUALISED NATURAL SCIENCES INTERVENTIONS IN MPUMALANGA

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ABSTRACT: The purpose of this paper is to explore the effectiveness of Natural Sciences interventions in one of the circuits in Mpumalanga. This paper uses pedagogical content knowledge and the instructional learning theoretical framework as a lens. Based on the outcome of baseline assessment of teaching practices in Natural Sciences in Grade 7, this paper adopted a qualitative research approach, using single case study design to explore the impact of interventions to assist teachers with content knowledge and teaching strategies that could be used for teaching Natural Sciences. Through observation and face-to-face interactions, this paper employed the purposive sampling method to select five teachers who participated in the interventions. The results of the paper suggest that science teachers in primary schools are still facing challenges such as a lack of resources, content knowledge barriers and neglection. Furthermore, teachers expressed an opinion that following the interventions they would now be able to transform content knowledge into practice. The study recommends that the Department of Education should consider extending similar kind(s) of workshop presented to secondary school teachers to the primary school teachers. Earlier interventions would not end at elongating learners' exposure, but would help to stimulate confidence, efficacy and mastery of sciences.

Keywords: Natural Sciences, pedagogical content knowledge, instructional theory, interventions

INTRODUCTION

In the 21st century teaching and learning of science requires dedication, passion and hard work. Although this demand is by no ways new, the advent of the so called fourth industrial revolution has attracted new interest in sciences as tributaries of technology. Over the years, South African Education system experienced a decline in the number of critical science professionals such as engineers, technologists, quantity surveyors, scientists, space and solar physicists, etcetera (South African Department of Labour, 2019). In trying to improve science related professionals, the Mpumalanga Department of Education (MDE) introduced science subject as compulsory to a sample of selected schools. This intervention resulted to about 101 schools in Mpumalanga having to intensify their focus on teaching mathematics and physical sciences as core subjects in the Further Education and Training Phase (FET) – Grade 10 to 12 (MDE, 2018). Despite efforts that were aimed at ensuring that learners were taught science in the upper grades of the selected schools, the number of learners who enrol in Mathematics Science and Technology (MST) schools has dropped drastically. This seems to be a general trend in the entire throughout the province, in most schools the number of learners who take science as a major subject in FET is on the decline. This can be attributed to a number of factors including the returning perception that science is difficult and challenging. The problem is further compounded by the scarcity of programmes that are intended to capacitate Natural Sciences (NS) teachers in schools in a sustainable way. Against this background this paper explores effectiveness of NS existing intervention in selected schools in the Bohlabela district in northern areas of Mpumalanga.

This paper used observations as baseline assessment that resulted in teachers who teach NS in the lower grades (Grade 7 to 9) raising the need to be assisted with content knowledge, assessment and teaching strategies. As a result, this paper focusses on Grade 7 NS teachers

who needed support in the form of interventions based on the following content: Planet Earth and Beyond, Matter and Materials, Energy and Change and Life and Living. Most of the teachers needed intervention in the content based on Planet Earth and Beyond. Few teachers requested interventions in Matter and Materials, Energy and Change and Life and Living although some of them requested interventions in the previously mentioned topics, it was discovered during the interventions that there are teachers who find some of the topics in Natural Sciences challenging. The two research questions of this paper were:

- What are the challenges faced by teachers when teaching Natural Sciences in Grade 7?
- How effective were the reconceptualised Natural Sciences interventions to Grade 7 teachers?

The following sections of this paper will review the literature, theoretical framework, results of this study, discussion of the results and the conclusion.

LITERATURE REVIEW

The paper explored the effectiveness of the reconceptualised NS interventions, which was the strategy that the researcher used in trying to reskill NS teachers of Grade 7 learners. Mpumalanga is facing a decline in the number of learners who enrol for pure science subjects in the FET phase. This could relate to a number of factors including lack of motivation on the part of learners to take science as their major subject in the FET phase. It can be anticipated that if this phenomenon is left uncorrected it has dire implications on retaining scientific knowledge in the long-term. For instance, Vedder-Weiss and Fortus (2018) indicated that the decline in motivation of adolescents to study science has resulted in a reduced number of science-related professions. Vedder-Weiss and Fortus (2018) further note that the decline in science-related professions is directly linked to teachers' involvement in the classroom. In other words, corrective measures that would promote learner interest in sciences begins with the science teachers – their mastery of content knowledge, beliefs, and motivation. Where teachers do no longer believe in the usefulness, worth and value of sciences it cannot be expected that there will be improvements on the downward slope of learner selection of science as reliable pathway for their choice careers.

Ediger (2018) contends that science teachers need to provide science content in an interesting manner to arouse the interest of leaners to become ready for science-related careers. Teachers who play an important role in teaching learners science subjects in the lower grades (primary school) might not always see it as their responsibility to motivate learners and teaching them with confidence they could pursue science at higher levels (secondary school). Researcher Akcay (2017) followed by Vedder-Weiss and Fortus (2018) are in agreement that learner support is needed, however this research identified differences in autonomous support between traditional and democratic schools. Traditional schools tended to follow archaic methods in which learners had partial involvement (if any) when identifying areas of support. This kind of learner exclusion often did not help to stimulate learner-interest. On the other hand, democratic school tended to rely on learners to make their own improvisation to generate their own learning. It is said that, teachers tended to cascade traditional science teaching to leaners, which result in the leaners not having opportunities to identify a problem or issue of personal interest (Akcay, 2017). Limitations of the latter approach is that learners cannot be expected to know about all their needs, teachers with expert knowledge need not desert their duty. In the end both the traditional and democratic approaches have strengths and weaknesses. The burden lies with teachers to gain expert knowledge about ways of stimulating learners' motivation for science take-up.

According to Akcay (2017), science teachers should focus on the personal needs of leaners; that is, science concepts and process skills that are useful in the daily living of learners. Akcay (2017) is of the view that if teachers embed societal issues in their teaching of science, which could include issues and problems at home, school, in the community and globally, they are more likely to see the relevance of science in their life and develop interest in science-related subjects. A good science teacher is observant if learners are engaged in learning and should be skilful and knowledgeable in selecting an appropriate method that applies to the evaluation process (Ediger, 2018). Thus, this paper explores the revitalised NS teacher's intervention that aims at improving the content knowledge and teaching strategies of teachers that might indirectly motivate learners in the classroom. To assist science teachers, like the respondents in this study, Bantwini and Feza (2017) draw attention to the need of continuous professional development of science teachers that improves their contextual needs, rather than a generalised version of it. In addition, teachers in the lower grades need to attend workshops frequently so that they are kept abreast with the ever-changing curriculum needs (Bantwini and Feza (2017). This paper explores the effectiveness of NS interventions where evidence has shown in other studies that classroom engagement is affected by classroom factors such as connective instruction, academic rigour and participatory teaching (Cooper, 2014).

THEORETICAL FRAMEWORK

The premise of this paper is pedagogical content knowledge (PCK) and instructional theories. On one hand, Shulman (1986) theorised that an expert science teacher knows the difficulties learners face and the misconceptions they develop. On the other hand, teachers should know how to utilise prior knowledge while presenting new ideas to help the learners develop a new and correct understanding which Schulman (1986) refers to as PCK. Bransford, Brown and Cocking (1999) noted that using PCK, teachers must firstly have an understanding of their subject (NS); secondly, they should know about the conceptual barriers that learners encounter in the subject. Lastly, the teachers should be acquainted with knowledge of effective strategies to work with learners. In this paper, PCK was chosen because it focusses on the content to be taught that teachers must possess to transform content knowledge into teaching. However, Bloom (1956) theorised instructional theory that is influenced by three basic theories in education, namely the theories of behaviourism, cognitivism and constructivism. Instructional theory explores how to help learners gain a better understanding of content (Bowden, 2008). The instructional theory also identifies strategies to be used in teaching and is adapted to the educational content and significantly on the learning style of the learners (Bowden, 2008). Therefore, this paper recognises the five universal methods of instruction: task-centredness, demonstration, application, activation and integration principles (Reigeluth, 1999). Reigeluth (1999) further contends that the main target audience of instructional theory is educational practitioners. Consequently, this is one of the reasons why this theory has been chosen for this study as the researcher explores the effectiveness of the reconceptualised NS interventions in Mpumalanga.

RESEARCH METHODOLOGY

This paper employed a qualitative research approach to find out the challenges and explore the effect of the reconceptualised NS intervention on teachers in the province. MacMillan and Schumacher (2010) revealed that qualitative research is used when little is known about a topic or phenomenon and when one wants to discover or explore further about the inquiry.

Research context

The qualitative study was undertaken in one of the four districts in Mpumalanga in the Agincourt circuit. Five schools were purposively sampled and five teachers were observed in baseline assessment while teaching NS in the classroom. The findings of the observation necessitated the researchers to conduct interventions for the Grade 7 NS teachers. The school

selection criteria were as follows: they all reside in the same circuit and they are primary schools with classes starting from Grade 1 to Grade 7 and NS is one of the subjects taught in the school.

Research design

The paper used a single case study of Agincourt circuit where the teachers who participated in the observation were sampled. Creswell (2009) contends that a case study is a strategy of inquiry where the researcher explores a programme, event, activity and process of one or more individual. Similarly, cases are complex organisations that have parts and act or operate in their surroundings, as shown in this paper. According to Johnson and Christensen (2008), a case study is mostly used in education where the goal is to explore a programme and evaluate its effectiveness. This paper indeed explores the effectiveness of NS interventions.

Participants and data collection methods

The participants in this paper were sampled from all teachers who took part in the baseline assessment during observations. Nineteen teachers took part in the observations and the researcher conveniently selected five teachers from five schools in the circuit for interventions. All the participants taught NS in Grade 7. The age range of the participants was between 24 to 55 years, showing that the sample included inexperienced and experienced teachers. In the baseline assessment, data was collected, using observations and the NS interventions took the shape of face-to-face interactive discussions with each participant. According to Yin (2011) in qualitative interview a researcher can interview either a group of participants (focus group) or individuals. Creswell (2009) points out that an interactive interview is a useful tool when participants cannot be directly observed and they can provide more information during interviews. In the instance of this paper, the interviews were interactive in that reconceptualised intervention took place. The instruments used were observation and face-to-face interviews with open-ended questions posed to the NS teachers. Each teacher was exposed to presentations of NS content, using PowerPoint.

Data analysis and Ethical consideration

The procedure for data analysis in this paper was adopted from Creswell (2009) and involved the following steps: **Step 1:** Organising and preparing the data for analysis. This involves transcribing interviews, typing of field notes and arranging the data into different types depending on the sources of information provided. ***Step 2:*** Reading through all the data. **Step 3:** Conducting a detailed analysis of the coding process done at that stage. Data in this study are organised into segments**. Step 4:** Involves the coding process used to generate a description of the setting, people, and categories. **Step 5:** Emerging themes from the categories. This paper has the approval of the UNISA College of Education Research Ethics Committee. All ethical-related matters such as informed consent and assent, anonymity of participants, trustworthiness and so forth were considered during data collection and analysis.

RESULTS

Observations and face-to-face interviews revealed that most teachers both experienced and inexperience are facing challenges of teaching overcrowded classrooms; a lack of teaching resources; a lack of in-service training and workshops on NS. In addition, teachers find themselves teaching NS out of specialisation – NS was not their major subject in tertiary education. While observing new and experienced teachers in the classroom, it emerged that some of them still have **misconceptions** about certain topics of NS. The teachers also revealed that they have challenges when transforming **content knowledge** into teaching and a lack of necessary **teaching strategies** that could be used in NS. As a result, the teachers requested interventions that were conducted by specialists in NS through a community engagement project. They requested to be capacitated the following content in Grade 7;

Matter and Materials, **Planet Earth and Beyond** and **Energy and Change**. The results of this paper also suggest that the teachers benefitted from the interventions which were based on issues such as misconceptions, transformative teaching, difficult topics in the NS curriculum and strategies that can be used to teach practicals in the classroom.

DISCUSSION OF RESULTS

The discussion of results focusses on the effectiveness of the NS intervention for teachers with respect to two themes that emerged, namely content knowledge (transforming content knowledge into effective teaching and misconceptions) and teaching practices (strategies).

Content Knowledge

The teachers raised challenges in teaching Matter and Materials, Planet Earth and Beyond and Energy and Change; this was evident during the classroom observations while teaching NS. The teachers were then invited to individual discussions on content that is challenging to teach in the classroom. In Planet Earth and Beyond most teachers could not explain how they could teach the topic 'tides' in the classroom; explaining it to learners is therefore a challenge. This scenario was observed in both inexperienced and experienced teachers. During the interventions, they were provided with NS topic-specific videos that could be used in the classroom to explain how tides are formed. Again, the challenge of most schools was the unavailability of overhead projectors and laptops that could be used to teach such topics in the classroom. The teachers were also provided with a practical explanation of the relationships of the sun to the earth, relationship of the moon to the earth and historical development of astronomy during the interventions. Some teachers were then afforded the opportunity to probe further into content that is problematic, leading to conducive dialogic conversations between the researcher and the teacher. The interventions also improved the new and experienced teachers' understanding of the use of indigenous knowledge in NS topics. For example, in some South African cultures lunar eclipse represents a year of good harvest and prosperity meanwhile in other cultures it represents suffering and bloodshed. The teachers were capacitated to relate indigenous knowledge to science.

In Matter and Materials, inexperienced and experienced teachers were capacitated to use indigenous ways of separating mixtures, such as distillation. The teachers also had misconceptions in respect of Matter, Materials, for example that steam is hot air instead of being water vapour and that ice molecules are colder than water molecules instead of teaching that ice molecules have less kinetic energy than water molecules. Furthermore, some teachers taught the learners that condensation on the outside of the container is water that seeped through the walls of the container instead of saying that condensation of water vapour happens when the water vapour in air comes in contact with a cool surface. This confirms the instructional theory that identifies strategies to be used in teaching and is adapted to the educational content and significantly on the learning style of the learners (Bowden, 2008). In Energy and Change, teachers found the difference between potential and kinetic energy challenging and during the interventions, they were assisted in that practical examples were given to them that they can use in the classroom when teaching NS. Other studies have found that in-service education might assist new and veteran teachers with knowledge and skills that optimise learner achievement and progress (Ediger, 2018; Akcay, 2017; Brauer & Wilde 2018; Akpan, 2017). While other studies focused on transformative sustainable learning of science (Harmin, Barrett & Hoessler, 2017) and the implications of socio-scientific issues to improve critical thinking competences (Solbes, Torres & Traver 2018). What this paper finds different from the reviewed studies is that the analysis is based on the exact content that teachers felt in need to be assisted and the utilisation of specific ways of teaching NS, using indigenous knowledge, clarifying content barriers and using modernised teaching strategies in primary schools.

Effective Natural Sciences teaching practices

In this study, it was observed that most teachers still rely on traditional teaching methods for NS. For example, “chalk and talk” method, the lecture method, the teacher-centred approach and the teacher is in control and makes the decisions. According to www.rnitte.edu.pk (2019) these traditional methods encourage learners to master knowledge through drill and practice. The interventions encouraged both inexperienced and experienced teachers to employ modernised teaching strategies, such as visualisation, for example, pictures, diagrams and videos that would help teachers to review existing knowledge and help to introduce new knowledge (Farra & Rashid 2013). Other strategies that NS teachers should use are problem-based learning, small group discussions, social networks, such as WhatsApp, and collaborative teaching and learning. In support of these findings, Vedder-Weiss and Fortus (2018) contends that the learners should be allowed to make choices in their learning regarding aspects such as seating arrangement; content of assignment; groupings and methods of assessment. Akcay (2017) also draws attention to problem-based learning that it is important in science education where students develop skills, which allow them to become active, responsible people by responding to issues that affect their lives.

In support of small group instructions, Ediger (2018) believes that these instructions may engage learners in identified problems to solve from video presentation. For example, teaching the topic 'tides' in the NS classroom. The suggested strategies in teaching NS sought to present a teacher as a facilitator that guides learners where learners are the decision-makers and the master of knowledge by constructing it. The interventions also educated teachers in the importance of using PowerPoint presentations and worksheets for each topic on NS that is taught in the classroom. The findings of the paper anchor the sentiment of Bantwini and Feza (2017) who mention that there is a need for teacher support by school districts on how to teach the 21st century learner, including differentiated curriculum, instruction and assessment intended to deal with the needs of various learners and the mixed ability of learners in the in their classrooms. Most of the teachers were of the opinion that the interventions were necessary, they were revived in teaching NS, and they would implement all the recommendations made by the facilitators. To signify the importance of the interventions, most teachers encouraged the facilitators to avail themselves whenever they are needed.

CONCLUSION AND IMPLICATIONS

The findings of this study illustrate that new and experienced science teachers have massive responsibility not only to overcome the lack of teaching resources in the study area, but also to have them motivated to overcome content knowledge barriers and be in a position to transform content knowledge into practice in the classroom. Based on the two research questions of this study, it is important to note that the teachers have challenges in teaching NS and that the reconceptualised interventions on NS assisted them in finding a way forward to teach NS in future in a modernised society. This paper recommends that workshops be presented to all teachers, regardless of the grade they are teaching, so that they are kept abreast with the modernised curriculum and that they are able to transform content knowledge into teaching in the classroom. Further studies can be conducted on how effective the suggested teaching strategies to NS knowledge acquisition by learners.

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