Vol. 74 | No. 6/1 | Jun 2018
DOI: 10.21506/j.ponte.2018.6.9

PONTE
Florence, Italy
International Journal of Sciences and Research

NATURAL SCIENCES INSTRUCTION: INTERROGATING EASTERN CAPE TEACHERS' INSTRUCTIONAL METHODOLOGIES

Nomxolisi Mtsi[1], Newlin Marongwe[*2], Grasia Chisango[1], Elvis T. Matyedi[1]

[1]*Faculty of Education- Department of Curriculum Studies, Walter Sisulu University*
[2]*Division of Academic Affairs & Research Development, Walter Sisulu University, ,*
nmarongwe@wsu.ac.za

ABSTRACT

The paper assesses the pedagogical methods used by teachers in the teaching and learning of Natural Science (NS). The study was informed by the social constructivism, located in the interpretivist paradigm. A qualitative approach and a case study design were utilised. A purposive sample of three principals, three teachers and eighteen learners participated in the study. Data were collected through interviews, focus group discussion and lesson observation. Data were analysed for content. The study found that teachers were not using the current pedagogies that promote the learning of NS. The paper concludes that the effective learning of NS is severely compromised if teachers have challenges in pedagogical methods. School staff exchange programmes should be encouraged.

Keywords: Natural Science; Curriculum interpretation; Professional development; Pedagogy; Support; Intervention strategies

INTRODUCTION

Critical pedagogy is the most effective style of facilitation, as it hands over the responsibility for learning to the learners and to think critically on scientific issues studied as well as study them in context (Ramesh and Patel 2013). Critical pedagogy can be used in teaching science to improve the performance of learners and to make the lesson interesting, and will also assist teachers to identify the approach that suits the environment they are working in. This allows learners to work in groups and link the new science concepts to what the learners already know. The study sought to understand the extent to which the critical pedagogy is applied in

the rural context so as to improve the learning of NS in the rural schools in Eastern Cape South Africa. In addition the study wants to assess the teaching and learning methods employed in the teaching of natural science. The study used Grade 9 classes as explained on the population and sampling section.

The purpose of this study was to ascertain the teaching approaches employed by teachers in teaching different NS topics. The assumption was that a trained teacher who is a science specialist is prepared to teach the subject using different teaching and learning approaches and ensuring that learners understand the concepts taught. In line with social constructivist approaches, the researchers were also interested in establishing how learners were involved in the actual learning of science by actually participating as individuals and as groups.

PROBLEM STATEMENT

The problem that is puzzling the researchers is why Grade 9 learners continue to fail Natural Science despite resources being channelled by the government towards the teaching and learning of NS. Media reports has that Eastern Cape is grappling with high failure rate at Grade 12 and Grade 9 levels. The reporter Mvumvu (2018, 4) reports, “The Eastern Cape is battling a problem of an increasing failure rate in Grade 9, with figures standing at a shocking 37% of pupils who do not progress to Grade 10”. This was a cause for concern to the researchers and they found that one of the subjects learners underperformed in was Natural Science. Hence undertaking this study to ascertain the teaching approaches employed by teachers in teaching different NS topics and establish the extent to which the critical pedagogy is applied in the rural context so as to improve the learning of NS in the rural schools in Eastern Cape South Africa.

THEORETICAL FRAMEWORK

Swanson (2013) says that a theoretical framework introduces and describes the theory that explains the research problem under study. A theoretical framework, provides the lens through which the research study is viewed and assists in better understanding the phenomenon under study. This is consistent with the view advanced by McGaghie, Bordage and Shea (2010, 923) that theoretical framework always underlies a research study. The study was informed by the social constructivism since the study is dealing with instructional methods. Zhu, Ennis and Chen (2011) ascertain the key features of constructivist theory of learning which are:

- The learner is actively engaged in learning
- The learner's experiences are important in learning
- The learner personally constructs meaningful understanding of concepts.

Social constructivism fits very well in the study since it is assumed that reality is constructed through human activity (knowledge is created through interactions with others, and their environment and learning is more meaningful when the learner is socially engaged) (Vygotsky 1978). The core of the above theory adopted in the study is discovery learning and that students learn best by doing (Ouyang 2014). Constructivism applies to science teaching and learning because the theory encourages learning based on active techniques such as experimentation and problem solving. The role of the teacher is to facilitate learning by providing materials, resources and tasks to ensure that learners engage in learning. In investigating factors affecting the teaching and learning of Natural Science, the role of the teachers, learners and resources was considered as informed by the constructivist theory of learning. In this theory, students are actively involved in their own process of learning. The teacher is a facilitator who prepares, mediates and helps students develop as well as assess their understanding.

PURPOSE OF THE STUDY

The purpose of this study was to ascertain the pedagogical methods used by teachers in their Natural Science classes.

RESEARCH QUESTIONS

The study sought answers to the following research questions:

- What are the teaching and learning methods employed by the teachers in the teaching and learning of Natural Science?
- To what extent is the critical pedagogy applied in the teaching and learning of Natural Science in the rural context?

OBJECTIVES OF THE STUDY

The study objectives were to:

- Establish the teaching and learning methods employed in the teaching and learning of Natural Science.
- Explore the extent to which the critical pedagogy is applied in the rural context in the teaching and learning of Natural Science.

LITERATURE REVIEW

According to the Department of Basic Education (2011c, 10) Senior Phase policy document, 'Science' is a systematic way of looking for explanations and connecting the ideas we have. In Science certain methods of inquiry and investigation are generally used. The methods include formulating hypotheses, designing and carrying out experiments to test the hypotheses. The researchers emphasized that the teacher's duty is to use these methods to enhance the teaching and learning of science.

Science teaching is characterised by a multiplicity of approaches (Duckworth 2006). Use of different approaches in teaching science helps to accommodate learners with challenges. Cimer (2007) observes that there are six principles of effective teaching of science which act as teaching approaches that allow learners to construct their own understanding and knowledge. Cimer (2007) further states that these principles, which contribute to effective teaching, derive from constructivist ideas in teaching and learning.

The first principle involves dealing with learners' existing ideas and conceptions. Tytler (2002) notes that learners' existing ideas and conceptions have been identified as valuable considerations in science teaching and a necessary part of teaching strategies. Tytler (2002) observes the common belief that learners do not arrive in the classroom as empty vessels into which new ideas can be poured by teachers hence teachers should utilise learners' prior knowledge. Tytler (2002) further observes that learners' existing ideas and conceptions in science increase students' awareness of them. In this principle, there are teaching methods that can be used to make a lesson successful not by just presenting information to learners directly from the text but by providing demonstrations and activities. This is the learner-centred aspect of the constructivist view of learning as discussed on the theoretical framework above. Amos and Boohan (2002) observe that the question and answer method is

the most common method used to stimulate learners and expose their informal, and perhaps distorted, preconceptions developed through their everyday experiences to facilitate their recalling ideas from their long term memory.

The second principle encourages learners to apply new concepts or skills into different contexts. Effective learning requires learners to apply newly acquired concepts or skills to different contexts (Gallagher 2000). This potentially leads to higher learning outcomes and application of knowledge or skills to solve everyday problems.

The third principle is based on encouraging student participation in lessons. Research shows that the more learners are involved in the learning process, the more they learn (Trowbridge, Bybee and Powell 2000). Many different methods and strategies have been suggested for involving learners in lessons and engaging them in active learning (Deboer 2002; Goodrum, Hackling and Rennie 2002; Trowbridge, Bybee and Powell 2000).

According to Cimer (2007), the fourth principle is encouraging student enquiry. Trowbridge, Bybee and Powell (2000, 207) define inquiry as "the process of defining and investigating problems, formulating hypotheses, designing experiments, gathering data and drawing conclusions about problems". Through scientific inquiry, learners are not passive receivers of information but actively engage with content to derive meaning out of it. The role of the teacher, in this regard, will be to facilitate learning.

Offering continuous assessment and providing performance feedback is also another important principle. Effective teaching requires teachers to check continuously students' understanding and give detailed positive feedback which helps students correctly integrate new knowledge into an existing knowledge structure (Cimer 2007). The methods that can be used according to Cimer (2007) are formative assessment and self-assessment. Amos and Boohan (2002) argue that the use of higher order questions enable learners to apply, analyse, synthesise, and evaluate information, which were considered as high order thinking skills in Bloom's taxonomy (Bloom 1956).

Research illuminates the many pedagogical, organizational and didactic difficulties teachers face in providing inquiry-based education (Kim and Tan 2011). Teachers need competencies to guide the inquiry process. Luera and Otto (2005) noted that as a result of research advocating inquiry-based education, inquiry based science teaching and learning has become

the focus in policy documents. Poor or insufficient guidance and feedback offered during the instructional process negatively affects learning (Kirschner, Sweller and Clark 2006). Alarke – Tuanter, Biemans, Tobi, Wals, Oosterheert, and Mulder (2012) identify twenty three elements of competencies. These competencies were categorised in the groups' subject matter knowledge (SMK) elements, pedagogical content knowledge (PCK) elements, and attitude elements. Kleickmann et al. (2013) state that Pedagogical Content Knowledge (PCK) and Content Knowledge (CK) are key components of teacher competence that affect students' progress. In order for one to teach effectively, knowledge of the subject should be detailed, and the teacher should be an expert of the subject. Subject matter knowledge (SMK), also known as content knowledge (Shulman 1992) encompasses the theories, principles and concepts of a particular discipline that is to be learned and taught. Shulman states that SMK is the amount and organization of knowledge in the mind of teacher. Avraamidon and Zembal-Saul (2010) states that SMK is necessary but not sufficient for effective teaching. Teachers also need knowledge that blends subjects matter and pedagogical knowledge. Kriek and Grayson (2009) indicate that there are serious concerns about the state of science education in South Africa and further observes that concerns are around teachers' lack of content knowledge in science, challenges in use of appropriate teaching methods as well as unprofessional conduct (Dudu 2013). Teachers may be asked to teach Science when it is not their area of specialisation, due to staff shortage in schools.

Another method which can be used is inquiry based science education. Liang and Richardson (2009) define scientific inquiry as the diverse ways in which scientists study the natural world. Scientific inquiry involves a complex activity that involves "observations, posing questions, examining books and other resources of information to see what is already known, planning investigation, reviewing what is already known in the light of experimental evidence, using tools to gather, analyse and interpret data, proposing answers, explanations and predictions and communicating the results" (National Research Council 1996, 23). Scientific inquiry derives its basis from inquiry-based education which is born out of a mixture of the works of Jean Piaget, Lev Vygotsky and David Ausubel, within the philosophical nature of learning and teaching known as constructivism (Liang and Gabel 2005). The constructivist approach emphasizes that phenomenology is constructed through active thinking, the organization of the information and the integration of existing knowledge. Teachers need specific inquiry-based science teaching competencies to support and facilitate

students' learning (Kirschner, Schweller and Clark 2006). Teachers are supposed to use inquiry-based science competencies through experiments, problem solving and building upon learners' prior knowledge.

Inquiry instruction in science enables learners to formulate their own questions, devise ways to answer them through data collection and analysis and then determine the reliability of the knowledge acquired (Ackerson and Donnelly 2010). Literature in science education describes three levels of inquiry-based teaching and learning. These are structured inquiry, guided inquiry and open inquiry (Afonso and Gilbert 2010).

There are other different specific teaching and learning techniques that teachers can employ to ensure meaningful teaching of Science in schools. Hudson (2007) talks of the use of buzz groups, where group members participate in small sub-groups, and then take part in a discussion with the entire group, every group member is expected to participate and work together with other group members. According to Hudson (2007) another method is the use of panels, in which a selected group of learners with a leader talk about an issue in front of an audience, which is later incorporated. It is a technique that stimulates interest and thinking and provokes discussion. Symposia is another method where a topic is broken into various parts with each part presented by an expert or well-informed person in brief. The facilitator meets with three or four group members and plans an outline. Participants are introduced and given reports. Another technique is experience discussion, small or large-group discussion, which takes place following a report about the main theme of a book, article, or life experience. It is used to present a new point of view or an issue; to stimulate thought and discussion; and also in an open discussion on pertinent issues (Hudson 2007). We are of the view that if teachers could vary these methods then the results could be positive. These methods enhance and develop learners' thinking skills.

Jigsaws are a technique in which, according to Hudson (2007), all group members participate as both experts and learners. This is often followed by a problem-solving situation where all the knowledge must be used for the group to succeed. Students work in small groups (expert groups) to master the material. The facilitator rotates among the groups to answer questions and makes sure the material is being mastered and understood. Students return to their home groups, which include one member from each expert group. They teach each other their areas

of responsibility and then use the new knowledge to solve a problem, write a group essay or examination. In this technique all the learners become experts. It promotes responsibility and attentiveness as learners have to explain to their home group.

Also Youssef and Mohammed (2016) mentioned other methods that can be employed in the teaching and learning of science are: discovery method, transmission method, developmental views of learning, learning cycle and successful learning (Youssef and Mohammed 2016). Discovery method is a method that includes self-directed learning and the aim is to promote higher forms of thinking with the aid of metacognitive strategies. Alfieri et al. (2010) emphasized that in discovery method learners are required to discover information by carrying out investigation. Then the teacher is there to demonstrate in front of the learners and ask the learners to conduct the investigation. However, Marzano (2011) mentioned the use of enhanced discovery learning. The scholar above also highlighted that the enhanced discovery learning involves preparing the learner for the discovery learning task, by providing necessary knowledge needed to successfully complete the task. The above three cited works agree that discovery method allows learners to generate ideas about a topic and work together to solve problems which is the goal of science learning. This method is in agreement with the Department of Basic Education (2011c, 10) Senior Phase policy document which holds that Science is a systematic way of looking for explanations and connecting the ideas we have to make sense. It is in line with the principles of social constructivism adopted in this which promotes critical thinking.

There is also developmental views of learning as alluded to earlier on. This method involves children's abilities as they grow and become matured. Youssef et al. (2016) mentioned that the most influential theory in this method is the theory of cognitive development. It is whereby Piaget described the four stages of intellectual development. The first stage which is sensory motor stage, Piaget described it as a stage whereby children's intelligence is motoric and characterised by activities. They also learn through their senses. The second stage, preoperational which is described as the stage the child is not yet capable of using logical processes of reasoning. Another stage is concrete operational stage, the child in this stage is capable of using logical reasoning. The last stage is, formal stage it is where the child's thinking is not only abstract but also logical. They are able to generate potential solutions to

problems. From the above views, it can be noted that this method helps teachers to give suitable tasks according to the level of the learners to challenge their thinking capacity in an interesting manner. It is a method that encourages students to develop their own understanding of a science concept, explore and deepen that understanding and then apply the concept to a new situation (Youssef et al. 2016).

Science and ICT **is** another instructional method in the teaching and learning of Natural Science and Information and Communication Technology (SICT). The use of SICT in the classroom promotes the teaching and learning. The teachers are able to integrate the lecture method with SICT to bring deep understanding of the science concepts. For instance to understand the concept photosynthesis, the teacher can let the students watch the videos to see the practical part of the concept. It makes life easier for learners as they are exposed to researching techniques using computers. Leaners will also be able to keep information in electronic version. Frost (2009) and Toyama (2009) state that digital technologies can help develop learning in science processes. The author above further mentioned that the digital technologies can support students with data collection, data analysis and presentation.

There is also generative learning theory that is based on the idea that learners can actively integrate new ideas into their memory to enhance their educational experience (Pappas 2014). Pappas states that there are four key concepts of generative learning theory which are: recall, integration, organisation and elaboration. Recall- occurs when the learner accesses information stored in the long term memory. The aim is to encourage learners to learn content that is based upon facts by using information they have already acquired. Integration- involves the learner integrating new information with knowledge already collected and stored. The aim is to alter the information into a form, which the learner can more easily remember and access it later on. Organization - involves learners linking knowledge they've already collected to new concepts in an effective way. Lastly there is elaboration which involves the encouragement of the learner to connect and add new concepts to information that they have already collected, by analysing the ideas. All the methods discussed above are aimed at developing learners into discovering new knowledge with the teacher's assistance.

Creating positive learning environment is another instructional method, which Tweed (2010) states that elementary teachers are experts at creating a positive classroom climate. According

to Tweed (2010), there are five strategies to be used to engage students collaboratively to create the positive classroom climate. These strategies are**:** believing all students can learn – the teachers must convince students that she/he believes that they all have potential. Thinking scientifically – promote the skill of thinking scientifically e.g. integrate the theory with practical. Expose learners in science festivals and competitions. Developing positive attitude and motivation – motivate students and make them understand that everything is possible when you are more involved. Finally- teaching students to be metacognitive – Involve students in thinking about their ideas and assessing their own progress. From our own point of view, creating positive learning environment as an instructional method is not really different from other methods discussed above since the core is to make a learner develop his/her potential through working towards finding solutions.

Successful learning is also an instructional method used in the teaching and learning of science. This method concentrates more on learning. In this method, learning is seen as a process and it also means students making conscious efforts to achieve their personal education needs, interest and goals (Youssef et al. 2016). The authors noted that, this method involves the process of acquiring knowledge and skills through practice, teaching or information. Learning can be represented with the expected results, obtained by the students which can be the bases and means for further learning. The scholars continued by saying that knowledge should be used with meaning of decision making, problem solving, goals, experimental testing, investigation and analysis of the system. Furthermore they say learning is assessed by its results in relation to the objectives. This method again promotes a learner to make effort as an individual in order to succeed.

Youssef et al. (2016) state co-operative learning as another instructional method which organises students in small groups so that they can work together to maximise their own and each other learning. Co-operative learning students are arranged in pairs, or small group. Then small groups are structured for positive interdependence, face to face interaction, individual accountability and the use of interpersonal and small group of skills. The researchers concur with the authors above, co-operative learning should promote collaborative learning, whereby students will assist each other. They will also be responsible for the work given for the group. In addition the scholars also mentioned that co-operative learning has been found to be useful in several areas such as helping learners acquire the

basic co-operative attitudes and values they need to think independently inside and outside the classroom. The method also promotes critical thinking.

The last method to be discussed in this paper is the transmission method which is a lecturer method (traditional method) is still used in schools because of the lack of the resources. Youssef et al. (2016) noted that the transmission view of teaching and learning sees teachers as passing over their knowledge to their pupils. This view is strongly linked to expository teaching; teachers standing at the front telling their pupils about scientific ideas. The researchers believe that this method only allows the teacher to do the talking. Pupils are expected to listen and take the information as it is. This method is not promoting critical thinking. Again the scholars mentioned that despite the weaknesses of this method there are advantages like: It is easy to create interest in a topic or subject by the teacher. Students easily acquire knowledge, new information, and explanation of events or things. Lastly it helps students to clarify and gain better understanding of a subject, topic, matter or event. The researchers also concur with the scholars above and they furthermore mentioned the disadvantages of this method. Students are not participating in hands on activities. Consequently the method does not allow cooperative learning where students work in groups to share ideas.

METHODOLOGY

Approach: The study was located in the interpretive paradigm. Qualitative approach was utilised. Creswell (2008) defines qualitative as an inquiry process of understanding based on district methodological traditions of inquiry that explore a social or human problem. According to McMillan and Schumacher (2006, p.50) qualitative research is an inquiry in which researchers collect data in face-to-face situations by interacting with selected persons in their settings or research field.The researchers employed qualitative approach in order to ascertain the instructional methods employed in the teaching and learning of NS, looking at the depth of the problem. Leedy and Ormrod (2013) noted that qualitative researchers believe that there are many dimensions underlying the phenomenon so they look at the depth of the problem. The study followed a case study design. The case study design was adopted to engage in an in-depth study of principals, teachers and learners' views and experiences on the instructional methods employed by teachers.

Population and sampling: The school learners, science teachers and principals formed the population. Convenient sampling technique was employed to select the three schools that participated in the study. Purposive critical case sampling technique was utilised. Purposive sampling was suitable for the study because it allowed the researchers to select participants who were able to answer our research questions and provide rich data as they were all directly involved in the NS curriculum. Three principals, three Natural Science teachers (one per school) and eighteen learners (six learners per school) for Grade 9 participated in the study. For the purpose of this study twenty-four participants were selected and this number is large enough to provide meaningful responses to the questions asked in the instrument, small as it may appear, but the figure aligned to a qualitative approach. Cresswell (2008) substantiates this view when he argues that a sample size of this nature will suit the qualitative study. Terney and Dilley (2002) agree with this view when they note that a sample of twenty-four participants is small but theoretically significant. In support of Terney and Dilley, Paton (2002) also argues that in qualitative research, a researcher can even use single cases of N=1; with only one participant. Also Creswell (2008) as cited in Babbie and Mouton (2010) and Leedy and Ormrod (2005) suggest the use of 5-25 case, which have direct experience of the phenomenon under study. Slavin (1984, p.104) states, “a small carefully done study is better than a large, sloppy one …” Based on the above cited authors, we felt that the range was large enough to uncover most what the study was looking for.

Data collection techniques: Data were collected using individual interviews with school principals, Natural Science teachers and focus groups discussions with science learners as well as observations of NS lessons. The key focus of the discussions was to establish the teaching and learning methods that were used by teachers in Natural Science cases. Each focus group had six learners and averagely took about thirty minutes. The interviews took approximately between thirty and forty minutes. Both interviews and focus group discussions helped the researchers to probe and get inside the skin of the participants so as to understand from their own point of view. For crystallisation, the researchers observed educators (used in the study) teaching Natural Science in order to reconcile and augment the interviews and focus group discussions. The researchers wrote field-notes during the observation sessions. The observations were done each three times per school on different days and it helped the researchers to support the responses obtained from the interviews. An observation guiding

tool was used to establish whether the expected aims, approaches, resources were all both used and included in the lesson and in the classroom.

Data analysis and presentation: Content analysis was utilized to analyse data collected for the study. Researchers coded and categorised data to enable thematic analysis. Beginning with content analysis the researchers sought to extract themes and metaphors to organise and make sense of the data obtained. Responses were put into categories on the basis of the meaning they conveyed. Thick descriptions, verbatim transcriptions and narrations were used to present data.

Data trustworthiness: To ensure data trustworthiness participants were provided with feedback on the transcriptions of their individual responses to confirm whether the transcriptions were a true reflection of their views. Thus, they had an opportunity to provide their opinion regarding the accuracy of the interpretation of the transcriptions.

Ethical considerations

Permission to access schools and administer questionnaires was sought from the Provincial Department of Education, District Department of Education and principals of the participating schools. Participants were informed of privacy and confidentiality. The researchers explained to participants that they could withdraw at any time they felt like without any victimization. The authors explained the purpose of the study and conditions of participation before seeking informed consent from the participants. The authors also promised to hand a copy of their findings to the District Department of Education, of which they did.

RESULTS

Table 1 Codes for participants

PARTICIPANT CODE	FULL DESCRIPTION
PSA	Principal School A
PSB	Principal School B
PSC	Principal School C
SEA	Science Educator A
SEB	Science Educator B
SEC	Science Educator C
SLA	Science Learner School A
SLB	Science Learner School B
SLC	Science Learner School C

Themes drawn from the participants' responses on instructional methods employed in the teaching and learning of Natural Science

- Educator's awareness of different teaching and learning approaches.
- Different teaching and learning approaches employed
- Learner involvement in science learning
- Activities employed in science teaching and learning
- Extent to which critical pedagogy is used in the teaching and learning of NS

Educator's awareness of different teaching and learning approaches.

Participants revealed that educators were aware of the different teaching and learning approaches to be employed in the teaching and learning of NS. **PSB said,**

> *They are aware of the different teaching approaches and methods. Sometimes as I have been mandated to visit the classrooms they really use them e.g. Investigations and make learners work on their own in many different ways, as much as I am not very much well versed in the field of Science.*

The educators also confirmed this and **ESC** said, "*Yes I know group work; I involve my students using textbook method. Most of the time I use the telling method*".

Educators' awareness of different teaching approaches was confirmed by learners as **SLB** said, *"We work as groups" e.g. "After finished writing the presentation of the group one learner in the group goes in front of the classroom to present what we were discussing"*. It was clear from the responses that educators had an awareness of different teaching and learning approaches.

From the above verbatim quotations the participants showed knowledge of the traditional methods like the group work method. From all the study participants no one made mention of new approaches to teaching and learning of Natural Science as reflected in the literature review. The students also confirmed that they were familiar with group work approach as explained by ESC above. This provoked the researchers to find out whether the participants knew about the different teaching and learning approaches by asking them to mention or explain the approaches they were adopting in their classes that were enhancing the teaching of NS. Some participants could hardly point out the different approaches another than talking about group work and a telling method.

Different teaching and learning approaches employed

On different teaching and learning approaches it was indicated that educators actually employed different teaching and learning approaches**. PSA** said,

> *With the old system they use teaching resources, concrete resources; in the absence of teaching they use real objects like leaves, grass, etc. They are doing it to their best. They also use learner centred approach, student involvement. They are useful but not hundred percent.*

On the same issue, ***SEC*** *said, "I normally do experiments with learners, I allow them to carry out investigations and I also use the textbook method and rely on it since we lack resources".*

From the above responses, once again, it is clear that teachers in the study stick to old approaches and they thought that by holding experiments and showing the learners the grass it was all they could use. The literature above made reference to approaches like inquiry based science education approach, science and technology, discovery method, etc. It can be deducted from the data above that teachers were relying heavily on the same traditional methods. The participants hardly talked about other methods apart from group work and

telling method as reflected again under the first theme. The researchers inferred that the reason could be lack of resources in these rural schools under study. The teachers may be aware of those other approaches but limited by the environment hence reason why Natural Science is poorly performed in Eastern Cape rural schools as reported by the media. The study also concluded that some teachers were not skilled and competent enough to use approaches like science and technology. From the class observations made by the researchers, three rounds or times per school, it was evident that teachers were so accustomed to group work and telling methods with only two teachers who used experimental method. The data gathered through observation confirmed the data gathered through interviews and focus group discussions.

Learner involvement in science learning

In response to the involvement of learners in science teaching, **PSC** said,
I always see educators trying to let learners to work as groups and at times they do practical tasks" while **SEB** said, *"I involve learners using textbook method"*. Learners themselves confirmed being actively involved in learning as **SLB** said, *"We participate but it is not easy because we do not do some of the things since we do not have resources"*.

It was clear that educators would in some way involve learners through projects and carrying out of experiments but it was not always possible because of lack of resources and other constraints. This would lead educators to employ teacher centred approaches which were not very useful in science teaching. The issue of group work seemed to be the dominant approach at the expense of other approaches. Every participant was referring only to group work. To the researchers it was not convincing that the teachers know the different approaches because the situation on ground was not indicative of that. From the responses above SLB pointed out the issue of lack resources as indicated also by SEC on different approaches used, as a challenge. Surprisingly according to the data gathered through observation by the researchers, one school had expensive science apparatus, computers and projectors. The researchers inferred that the challenge was not a lack of resources but was that teachers did not know how to use the apparatus and some of the ICT gadgets at the school to enhance the teaching and learning of NS.

Activities employed in science teaching and learning

On activities employed in science teaching and learning, participants gave different views. **SEA** said, *"Learners work on some related activities like investigations and I also involve them in science projects"* and one **SLA** in contradiction indicated that: *"We do not do projects"*. **SEB** also expressed different view from the above: *"It becomes a problem when you don't have materials learners need to use, learning simply becomes theoretical"*.

From the above responses it can be depicted that educators were aware of the different traditional teaching and learning approaches and not employing other approaches that were more inclined to modern knowedge. Educators also attempted to involve learners in the learning of different concepts through group work and this was confirmed by the learners themselves. However, because of lack of resources, educators did not always involve learners in learning but would resort to the telling method at the expense of current approaches to the teaching of NS. Approaches such as group work and experiments were popularly employed. Educators also attempted to link NS concepts to what the learners already knew.

Extent to which critical pedagogy is used in the teaching and learning of NS

This part now presents data gathered through interviews and observations on ascertaining the extent to which critical pedagogy was used in NS classes. The participants were asked, 'To what extent was critical pedagogy effected in the teaching and learning of Natural Science? How does it affect the academic performance of NS learners?" Thus SEA explained that:

> *From my own experience it is difficult to tell because I know I am supposed to be using methods that promote NS learners to be critical thinkers, to discover knowledge on their own with my assistance but to be honest with you, the environment that we operate in doesn't allow that. Our learners are coming from backgrounds that force the teacher to adopt a narrative or group method only to make sure that they understand. Their academic performance in NS is poor I don't know how it would be if I were using critical pedagogical approaches.*

From the response above it is clear that critical pedagogy was not used to a greater extent and this confirmed data gathered through observation by the researchers. From all the class observations, the researchers did not observe an NS class that used either discovery method, adoption of ICTs, inquiry based, thinking scientifically, etc. We observed teachers commonly using the transmission and co-operative methods which are more inclined to traditional ways

of teaching. SEA above cited reasons like learners' poor backgrounds and the environment referring to lack of resources as why they were not using critical pedagogy. In agreement to the issues pointed out by SEA, SEB also cited challenges associated with using critical pedagogical methods. SEB highlighted that:

> *We don't have enough time to use those methods, we periods are so short and remember* NS *is not the only subject. We have a syllabus to complete. We don't have enough resources and it consumes a lot of time to organise students. Our learners are not exposed and used to technology and our school have very few computers. Most of our learners are shy to air their views or to use computers for fear of making mistakes and be laughed at by some students. Our students are at a critical stage of physical development so they are very sensitive.*

SEB's response confirms that learners are not being developed into critical thinking, innovative and most of the methods are teacher-centred. This contradicts the theory that underpinned this, the social constructivism which advances that learners should be actively engaged in learning and personally construct meaningful understanding of concepts leading to discovery learning. Constructivism applies to science teaching and learning because the theory encourages learning based on active techniques such as experimentation and problem solving. The role of the teacher is to facilitate learning by providing materials, resources and tasks to ensure that learners engage in learning. According to what SEB explained, sometimes learners fail not because they are not competent but because of the methods used and lack of relevant resources to enhance understanding especially science subjects that are challenging.

In the same vein SEC also indicated how difficult it was at their school to use more modern methods that lead learners to discover ideas with the assistance of the teacher as a facilitator. SEC thus articulated:

> *Our school has some of the resources like computers and other equipment though internet connection and power supply are sometimes a challenge. Personally I am not comfortable to blend ICT gadgets into my NS classes because I am not very competent and skilful. The training I received was just basic and it was not adequate for me to master everything and implement or apply in my class. To me I see it as time consuming and my students also struggle to use computers. The environment is not that developing and also the system tends to focus more on Matric classes at the*

expense of the lower classes. I know our learners are raw and they cannot compete with learners who are coming from rich environments hence seeing them failing dismally NS.

The researchers depicted once again that learners coming from that rural community under study are disadvantaged through the methods used in NS classes. SEC pointed out the issue of ICT use incompetence, lack of developmental support, and education officials paying special attention to higher grade classes. These points raised are a clear indication that yes, teaching and learning equipment/resources may be there but if teachers are not capacitated to use them they develop a negative attitude towards adoption in class. SEC stated above that she saw use of ICT gadgets as a waste of time because it consumes a lot of time to prepare, set up and use. From SEC's response it is evident that internet connectivity and power supply were a problem. From all the responses given by participants above, it can be concluded that critical pedagogical methods are not really used in NS classes though teachers were aware of the methods and this led to higher failure rate of NS as reflected by the study participants. Even the observations made by the researchers confirmed the data gathered through interviews that teachers were relying on teacher-centred methods.

DISCUSSION OF FINDINGS

It stemmed from the study that teachers were aware of different teaching and learning approaches but mostly employed the telling method, group work, text book and a bit of experiments. Educator participants admitted to using more of traditional methods in the teaching and learning of NS, and not using other methods that promote critical thinking and discovery of new knowledge by learners themselves due to lack of resources. The social constructivism theory that anchored this study believe in using methods that provoke learners to be critical thinkers and creators of knowledge through discovery ways. The above idea is line with Dudu's view (2014) who points out that inquiry approaches in science enable teachers to be creative and enrich students' abilities in understanding science concepts and processes. Dudu (2014) further underscores the importance of employing the appropriate teaching methods in science so as to develop scientific literacy among learners by engaging learners in scientific inquiry for them to develop broad knowledge and understanding of the processes and nature of science. In the same vein, Afonso and Gilbert (2010) advocate the use of pedagogical approaches that engage learners in critical thinking as well as application

of scientific concepts. The researchers are of the view that using different approaches when teaching NS, can enhance the teaching and learning of science as also spelt out by the study participants.

The study established that lack of resources sometimes bar teachers from using methods that promote creativeness when teaching and learning NS. According to the study findings, some rural schools are not well equipped and do not have adequate ICT gadgets that can be used to enhance the teaching and learning of NS. The above point confirms findings by Frost (2009) who states that digital technologies can help develop learning in science processes but the problem was shortage of modern resources in some schools. The paper also took note of the fact that in some rural schools resources were there but the educators were not really technologically oriented to adopt and use them in their classes. Some teachers were technophobic as well as students as established by Spelman and Marongwe (2017). Spelman and Marongwe (2017) carried out a study in Eastern Cape, South Africa using rural universities students and lecturers. They found out that some participants lacked technological skills and some were technophobic: that is fear of using computers. The current study established that if teachers are not using modern tools and methods, the leaners would also develop the same attitude and do not perform well in NS classes. Chigona (2011) also established that digitally incompetent teachers opt for traditional teaching methodologies. Some teachers lowly rate themselves in the use of ICTs in the classroom, hence perceive using technology as difficult as stated by SEC in this study. Some though ICT trained still fear making a technological mistake in class (Chigona 2011).

Another key finding of the study in the teaching and learning methods employed in NS was that students participated in experiments and science projects to a lesser extent because of lack of resources. Mostly teachers and learners in NS classes theorise lessons instead of doing it practically as suggested by social constructivism theory. His was clearly voiced by **SLA** and **SEB** who concurred that: *"We do not do projects", states **SLA** and* **SEB** also indicates *"It becomes a problem when you don't have materials learners need to use, learning simply becomes theoretical".* It was established by social constructivists that learning happens when learners construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences (Zhu, Ennis and Chen 2011). In support of the above idea Haslam and Hamilton (2010) highlighted that practical work at schools can

effectively and strongly support exploration and development of concepts especially in NS classes. The study as alluded to earlier on, also established that some participants in the study acknowledged that they had apparatus but do not know how to use them effectively. This idea corresponds with findings established by Mothlabane (2014) that although some schools had expensive apparatus but they lacked knowledge on how to use them. Mothlabane (2014) further mentioned that schools had been provided with equipment and do not make use of it. According to this study, teachers were then forced to use methods that were teacher-centred and promoting rote learning, learning by note taking and learners become passive recipients. Such methods create boredom in learners as the approach limits learner participation and reflection (Walkin 2000).

In response to, to what extent were teachers using critical pedagogical methods, it emerged from the study that teachers were not critically engaging learners. The teachers pointed out that use of only the traditional methods contribute to poor academic performance displayed in NS classes. The study also highlighted that the education support system was paying more attention to Matric classes and teachers in the lower grades were not competently developed to handle NS classes. The paper argues that if we want good results at Matric level, the lower classes should be cultured, developed, socialized and exposed to methods that promote them to become critical thinkers and innovative. There is a saying which says catch them while young so once correct methods are instituted at Grade 9, the system would know that the foundation has been set strong.

Conclusion

The paper concluded that educators were aware of the different teaching and learning approaches but heavily depending on traditional methods that do not promote learners to be critical thinkers or for them to discover and create knowledge. Reasons such as lack of resources, poor learner backgrounds, teacher incompetence to use apparatus and ICT tools and lack of support for Grade 9 recipients, etc. were advanced. Educators attempted to involve learners in the learning of different concepts by using experiments and project approaches but to a limited extent because of lack of resources. This compelled educators to resort to telling method for the sake of completing the syllabus as indicated by participants. It can also be concluded that both teachers and learners used in the study lacked exposure because of their environment.

Recommendations

In light of the findings the paper recommends the following:

- School exchange programmes where both teachers and learners get encouraged to learn best practices in NS teaching and learning from other schools.
- The Department of Basic Education should increase the number of professional development workshops in NS teaching to ensure adoption of critical pedagogical methods in classes.
- The school management team should ensure that schools have modern resources.

REFERENCES

Ackerson, V. and L. A. Donnelly. 2010. "Teaching nature of science to K-2 students: What understanding can they attain?" *International Journal of Science Education* 32 (1): 97-124.

Afonso, A.S. and J. K. Gilbert. 2010. "Pseudo-science: A meaningful context for assessing nature of science". *International Journal of Science Education* 32 (3): 329-348.

Alarke-Tuenter, E., H. J. A. Biemans, H. Tobi, A. E. J. Wals, I. Oosterheert and M. Mulder. 2012. "Inquiry-based Science Education Competencies of Primary School Teachers: A Literature Study and Critical Review of the American National Science Education Standards". *International Journal of Science Education* 34 (17): 1 - 32.

Alfieri, L., P. J. Brooks, N. J. Aldrich and H. R. Tenenbaum. 2010. "Does discovery-based instruction enhance learning?" *Journal of Educational Psychology 103* (1): 1-18.

Amos, S. and R. Boohan. 2002. "Aspects of Teaching Secondary Science". London: RoutledgeFalmer.

Bybee, R. W. 1997. "Achieving scientific literacy: From purposes to practical action". Portsmouth, NH: Heinemann.

Cimer, A. 2007. "Effective teaching in science: A review of literature". *Journal of Turkish Science Education* 4 (1): 21-44.

Creswell, J.W. 2008. "Research Design: Qualitative Quantitative and Mixed approaches". (3rd ed.) California: Sage Publications.

Deboer, G.E. 2002. "Student-centred teaching in a standards-based world: finding a sensible balance", *Science & Education* 11: 405-417.

Department of Basic Education. 2011b. "National Curriculum Statement: Curriculum and Assessment Policy Statement Grades 7-9 (Schools) Policy". Pretoria: DBE.

Duckworth, E.R. 2006. "*The having of wonderful ideas" and other essays on teaching and learning.* (3rd ed.). New York: Teachers College Press.

Dudu, W. T. 2013. *Grade 11 Learners' and Teachers' Conceptions of Scientific Inquiry in Relation To Instructional Practices*. PhD Thesis. Johannesburg: University of the Witwatersrand.

Dudu, W.T. 2014. "Exploring South African high school teachers' conceptions of the nature of scientific inquiry: A case study". *South African Journal of Education* 34 (1): 1 – 19.

Frost, R. 2009. "Datalologgerama". Available at: http://www.rogerfrost.com/ (Accessed March 18 2017).

Gallagher, J. T. 2000. "Teaching for Understanding and Application of Science Knowledge". *School Science and Mathematics* 100 (6): 310-318.

Hudson, P. 2007. "Theories and Approaches for learning and Teaching Science". Retrieved 10 March, 2017, from Queensland University of Technology, Online Learning and Teaching Web site: http://ltfiledown.qut.edu.au/download.asp?rNum=3272459&pNum=2237007&fac=edu&OLTWebSiteID=MDB006INT&dir=sec&CFID=134908&CFTOKEN=79794101. Accessed 28 March 2017

Kim, M. and A. L. Tan. 2011. "Rethinking difficulties of teaching inquiry-based practical work: stories from elementary pre-service teachers". *International Journal of Science Education* 33: 465 - 486.

Kirschner, P.A., J. Schwedler and R. A. Clark. 2006. "Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching". *Educational Psychologist* 41(2): 75- 86.

Kleickmann, T., D. Richter, M. Kunter, J. Elsner, M. Besser, S. Krauss and J. Baumert. 2013. "Teachers' Content Knowledge and Pedagogical Content Knowledge: The Role of Structural Differences in Teacher Education". *Journal of Teacher Education* 64 (1): 90–106.

Kriek, J., D. Grayson. 2009. "A holistic professional development model for South African physical science teachers". *South African Journal of Education* 29: 185-203.

Leedy, P. and J. Ormrod. 2013. "Practical Research: Planning and Design". New Jersey: Prentice Hall.

Liang, L. L. and D. L. Gabel. 2005. "Effectiveness of a Constructivist approach to science instruction for prospective elementary teachers." *International Journal of Science Education* 27: 1143-1162.

Liang, L.L. and G. M. Richardson. 2009. "Enhancing prospective teachers' science teaching efficacy beliefs through scaffolded, student-directed inquiry". *Journal of Elementary Science Education* 21: 51 - 66.

Luera, G.R. and C. A. Otto. 2005. "Development and evaluation of an inquiry-based elementary science teacher education program reflecting current reform movements". *Journal of Science Teacher Education* 16: 241 - 258.

Marzano, R. 2011."The Perils and Promises of Discovery Learning". *Educational Leadership* 69 (1): 86-87.

McGaghie, W.C., G. Bordage and J. A. Shea. 2010. "Problem statement, conceptual framework and research questions". *Academic Medicine* 76 (9): 923 – 924.

Mvumvu, Z. 2018. "Grade 9 failures are rising". *Daily Dispatch*, Thursday, 24 May, 2018 page 4. Available at: www.dispatch.co.za (Accessed May 24 2018).

National Research Council. 1996. "National Science Education Standards". Washington, DC: National Academy Press.

Pappas, C. 2014. "Instructional Design Models and Theories. The Generative Learning Theory". Available at: https://elearningindustry.com/generative-learning-theory (Accessed March 24 2017).

Piaget, J. 1972. "Intellectual Development from Adolescent to Adulthood". *Human Development* 15, 1-12.

Ramesh, M., and R. C. Patel. 2013. "Critical Pedagogy for Constructing Knowledge and Process Skills in Science". *Educationia Confab* 2 (1): 98 - 105

Shulman, L. S. 1992. "Ways of seeing, ways of knowing, ways of teaching, ways of ways of learning about teaching". *Journal of Curriculum Studies* 28 (1): 393-396.

Swanson, R. 2013. "Theory Building in Applied Disciplines". San Francisco, CA: Berret-Koehler Publishers.

Toyama, K. 2009. "Myths of ICT4D or NetHope without NetHype" NetHope Summit Redmond USA, 2009. Available at: www.research.microsoft.com/en-us/um/people/toyama/talks/... (Accessed March 20 2017).

Trowbridge, L. W., R. W. Bybee and J. C. Powell. 2000. "Teaching Secondary School Science". Upper Saddle River, NJ: Merrill / Prentice Hall.

Tweed, A. 2010. "Designing effective science instruction: what works in science classrooms". National Teachers Association Press. Available at: http://static.nsta.org/files/PB243Xweb.pdf. (Accessed 29 March 2017).

Tytler, R. 2002. "Teaching for understanding in science: Constructivist/conceptual change teaching approaches". *Australian Science Teachers Journal, 48* (4): 30-35.

Vygotsky, L.S. 1985. "Mind in society: The development of Higher Psychological Processes". Cambridge, MA: Harvard University Press.

Walkin, L. 2000. "Teaching and Learning in Further and Adult Education". Cheltenham, Stanley Thorne.

Youssef, S and C. Mahommed. 2016."Teaching Strategies for developing scientific literacy on students' achievement in Biology". *Asro Journal of Education* 1 (1): 6-19.

Zhu, X., C. Ennis and A. Chen. 2011. "Implementation challenges for a constructivist physical education curriculum". *Physical Education and Sport Pedagogy 16* (11): 83 - 99.