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Physical sciences teaching and learning in Eastern Cape rural schools: Reflections of pre-service teachers

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The experiences of pre-service teachers who come from rural backgrounds differ widely from those who are from urban schools. It can be assumed that these experiences play a crucial role in shaping their teaching careers during and after the formal teacher training. Even though much research has already dwelt on the various challenges experienced by rural schools in South Africa, little has been done on pre-service teachers' perspectives. Using an exploratory research method, this article explores the status of physical sciences teaching and learning in rural schools in one of the most disadvantaged provinces of South Africa, using pre-service teachers enrolled in a rural-based university as the participants. While many factors were reported as hindering the effective teaching and learning of physical sciences in rural schools, it was found that some schools and teachers used some appropriate strategies to promote teaching and learning.

Keywords: challenges; good practices; physical sciences education; pre-service teachers; rural schools; teaching and learning

Introduction

The role of a scientifically-motivated, young generation is undeniable for the sustainable economic growth of any country. Among the many science subjects in the school curriculum, Physical Sciences has a prominent role in determining learners' acceptance into various in-demand university degrees and specifically in the field of science and technology. Despite its key role in the economic growth of the country, South Africa has always been stymied by its learners' poor performance in Physical Sciences, both at national level (as evident from the matric examination results) and at international level (achievement tests such as Trends in International Mathematics and Science Study [TIMSS]). Additionally, the dismaying performance is often confined to Black and Coloured schools whereas performance of historically White and Indian schools remains far above the national average; this situation constrains both Black upward mobility in the labour market and the skills required for economic growth of a middle-income country like South Africa (Van der Berg, 2008).

The education in rural schools faces a unique set of challenges due to diverse factors such as geographic location of the schools, learners' backgrounds and learning styles (Nkambule, Balfour, Pillay & Moletsane, 2011). The Department of Basic Education (DBE) in South Africa has recently drafted a Rural Education Policy to improve access to education, as well as the quality of education for all in rural schools (DBE, Republic of South Africa, 2017). The policy defines rural areas as farms and traditional areas characterised by low population densities, low levels of economic activity, and low levels of infrastructure. It was stated in the policy that despite a number of pro-poor initiatives, which have been implemented since 1994 to promote equity and quality of education in previously disadvantaged schools including rural schools, a large number of rural schools are still characterised by inadequate resources, teacher shortages, absenteeism, learners' dropout from school, and poor educational outcomes (DBE, Republic of South Africa, 2017:8).

The challenges experienced in rural schools are not limited to developing countries like South Africa. Teachers in rural school in the United States of America are being burdened by heavy responsibilities such as teaching multiple subjects to multiple ability levels; this is often combined with insufficient mentoring, lack of administrative oversight, and insufficient pay (Howley, Rhodes & Beall, 2009). The authors also state that instructional practices in rural schools may constrain learners' individual opportunities for acceleration and remediation. Clearly, education literature on rural schools often portrays a picture of rural schools as being remotely located, serving communities with high poverty, declining populations, and limited economic opportunity (Redding & Walberg, 2012). The widespread challenges, which inhibit effective teaching and learning in rural schools all over the world, may lead to rural communities having limited access to economic development.

A few attempts have been made to explore South African learners' poor performance in Physical Sciences and Mathematics. One such study was carried out in the Gauteng province and reported on learners' and teachers' views about factors which led to poor performance in Physical Sciences and Mathematics (Makgato & Mji, 2006). Many direct and indirect influences were identified as hindering South African learners' performance in Mathematics and Physical Sciences. According to a statement released by the Eastern Cape Department of Education (ECDoE), the matric pass rate for the Eastern Cape province has slightly increased from 56.8% in 2015 to 65.1% in 2017 (ECDoE, 2018). However, taking into consideration the fact that the Eastern Cape province has long been considered as characterised by high levels of unemployment and illiteracy

(Department of Education Province of Eastern Cape, 2015) calls for extensive research at provincial level, especially in a rural context.

While various factors affecting poor performance in South African schools have been identified, outdated teaching methods such as the lecture method, which is popular and preferred by teachers, especially in subjects like Physical Sciences, have been a serious concern. This points back to the quality of subject-specific teacher training provided by higher education institutions in South Africa. During apartheid little provision was made for the Black majority to have the required number of quality teachers (Islam, 2012); the teacher training was done in racially-defined institutions to serve the needs of specific geographic areas, race, and ethnicity. Even after the dawn of democracy, the status quo remains, and mostly in rural schools.

Pre-service teachers themselves bring to the course their heritage of experiences of primary and secondary schooling (Samuel & Stephens, 2000). Teachers' classroom practices are affected by their own experiences of schooling, particularly with respect to their previous interactions with their own teachers (Nespor, 1987). This suggests that it is imperative to give pre-service teachers a space to critically reflect on the environments and contexts from which they come. The feedback on pre-service teachers' learned experiences can then be used as a starting point for adapting the teacher training curriculum to suit the specific needs of the community they intend to serve in their professional capacity. An attempt of a similar nature was made in the Kwa-Zulu Natal province by Samuel and Stephens (2000), focusing on the lives of two pre-service teachers who had intended to become English teachers. Even though this can be considered as a good start, the exploration of the contexts of just two schools may not be representative of a larger picture of the existing backgrounds in South African schools. In addition, since many of the challenges are encountered by education systems in rural areas, it is appropriate to explore the contexts in which rural schools specifically operate.

If rural communities around the world are to be supported, teacher education programmes need to prepare graduates specifically for teaching in rural schools (White & Reid, 2008). Supporting healthy rural communities by reforming teacher education programmes should be considered as a distinct call not only for teacher education institutions at rural places, but also for metropolitan-based institutions. As a result, Gruenewald's (2003) approach of creating place-consciousness among pre-service teachers as a pedagogical approach can be considered as an important element in fostering healthy and productive rural communities all over the world. Moreover, since the learning process cannot be separated from the environment in which it is constructed, it is imperative to probe into the contextual factors that contribute (both positively and negatively) to the physical sciences learning and teaching in rural schools.

Keeping the above points in mind, I aimed to provide pre-service teachers a chance to critically reflect on their (rural) school backgrounds and listen to their voices on the prevailing teaching and learning of physical sciences in rural schools in the Eastern Cape province in South Africa. The following research question was posed to achieve the above aim: What do pre-service teachers say about the physical sciences teaching and learning in rural schools in the Eastern Cape province?

The above question was addressed by asking the two sub-research questions:

1. What are the challenges encountered in rural schools in the effective implementation of physical sciences teaching and learning?
2. What are the factors which promote effective teaching and learning of physical sciences in rural schools?

Framework of the Study

The background of the study was drawn from a rural context. This was because of the nature of the participants of this study: teacher trainees enrolled in a rural-based university and who have come from rural high schools. Since it was highly likely that most of these teacher trainees returned to similar schools as in-service teachers, I assert that developing a place consciousness among the teacher trainees is imperative in attempting to assist them in becoming successful in their profession. White and Reid (2008) assert that teacher education programmes should integrate place consciousness into teacher education programmes as an integral part of preparing pre-service teachers for placement in rural schools. In this research, I sought to explore the current scenario in which physical sciences teaching and learning takes place in rural high schools in South Africa. However, I considered this project as the first step in the design of a bigger project in investigating ways in which teacher education programmes could be improved to meet the specific needs of rural South African schools, especially in the science education stream. I believe that to better understand the personal learning and teaching experiences of rural pre-service teachers, the lecturers should recall such experiences with their pre-service teachers in order to come up with pedagogic strategies, which might be successful – specifically in rural schools.

Gruenewald (2003) blends two educational traditions, namely, "critical pedagogy" and "place-based education" into "critical pedagogy of place." While critical pedagogy aims at challenging the assumptions, practices and outcomes taken for granted in a dominant culture and in conventional education, place-based pedagogy requires the education of citizens to have some direct bearing on the well-being of the social and ecological places

people actually inhabit. Critical pedagogy of place is useful in examining the place-specific nexus between environment, culture, and education and, as such, considers the nuanced qualities of rural life (Azano & Stewart, 2015). This research study intended to allow pre-service teachers to reflect critically on their personal experiences in rural schools. This spatial dimension may then be used to devise measures for social transformation in the rural educational contexts. The social transformation resulting from the place consciousness is the one which connects critical pedagogy to place-based education; this connection thus leads to critical pedagogy of place. Moreover, one of the crucial steps to prepare pre-service teachers for success in rural schools is to help them develop an awareness of how their cultural contexts shape their identities and teaching practices (Azano & Stewart, 2015).

I contend that when pre-service teachers are given space to critically reflect on their personal experiences in their rural high schools, they get an opportunity to remind themselves of the pedagogic practices (both successes and challenges) existing in rural schools. They can then use these experiences to think about how to become successful as in-service teachers in rural schools.

Even though this study was motivated by the principles of critical pedagogy of place, the framework of the study was guided by the principles of social constructivism, which postulates that construction of knowledge is the product of social interaction, interpretation, and understanding (Vygotsky, 1962). Thus, the creation of knowledge cannot be separated from the social environment in which it is formed (Adams, 2006; Woolfolk, 1993). Although, both school and home environments are part of the child's learning process, the focus of this study was restricted to the exploration of how the environment in rural schools contributed to the effective teaching and learning of physical sciences. Figure 1 depicts the conceptual framework of this study, which was derived from the assertions of social constructivism.

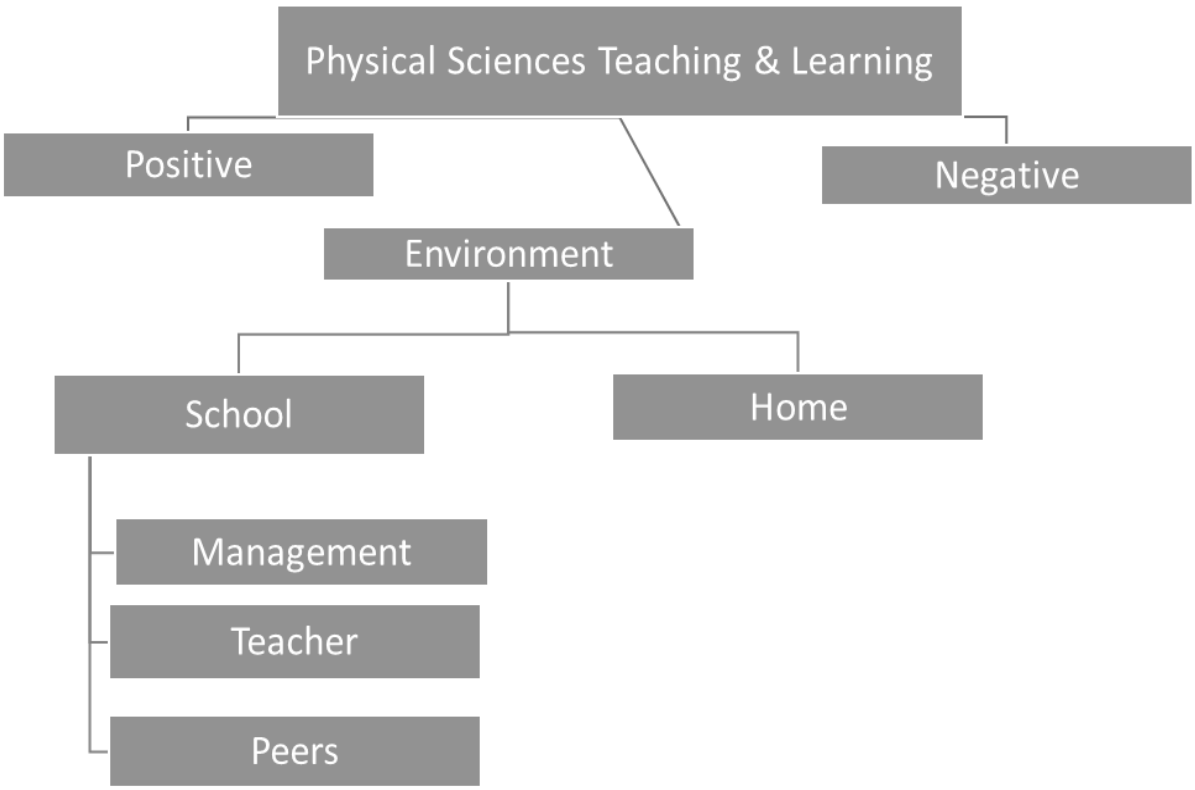

Figure 1 Conceptual framework of the study

It was assumed that three major school elements contributed to physical sciences teaching and learning in rural schools: the way in which the school is managed as a whole (management), the teacher and related factors (teacher), and the influence of the peers (peers) in the learning and teaching process (Figure 1). Consequently, the data collection instrument was designed to probe into the influence of the above three factors on physical sciences learning and teaching in rural schools.

Method

The study adopted an exploratory research method to understand the experiences of the participants. A questionnaire was used to collect data from the participants. The questionnaire consisted of ques-

tions on a) participants' biographical details, b) details about the schools in which participants completed matric, c) the quality of teaching and learning in these schools in general, and d) the quality of physical sciences teaching and learning, in particular. Since the scope of the current study was limited to rural schools in the Eastern Cape province, the responses to the questions of the first two sections (biographical and school details) were used to extract the desired participants and thus did not form part of the main data. The questionnaire questions were both multiple-choice and open-ended questions; most questions were open ended to extract as much information possible from the participants.

The population of the study consisted of all pre-service teachers enrolled for the third year of the Bachelor of Education programme in a rural-based university located in the Eastern Cape; this included only those participants whose major subject was Physical Sciences. The questionnaire was distributed to all 30 pre-service teachers who had registered at this level for the year 2017. However, it was explained to the participants that it was not compulsory to take part in this research. As a result, only 27 returned the completed questionnaires. Since the focus of the study was on rural schools in the Eastern Cape, the responses of those who were identified as being from provinces other than the Eastern Cape and urban schools inside/outside the province, were excluded in the reporting for this paper. (This information was extracted from the information received from the participants' responses to the first two sections of the questionnaire.) This resulted in the responses from only 19 participants being purposefully considered – 16 males and three females.

I adhered to all ethical requirements necessary to undertake this research project. Permission from the institution was granted and the participants (pre-service teachers) were told that their participation would be purely voluntary. I also ensured the anonymity of the participants by informing the participants that their names or student numbers would not be disclosed to anyone. However, for the purpose of reporting the findings in this paper, the 19 participants are named using codes PrT 1 to PrT 19 (where PrT stands for Pre-service Teacher).

Data Analysis

The questionnaire consisted of a few multiple-choice type questions and the responses to these were analysed using Microsoft Excel by determining the percentage of occurrence of various responses. Most of the items in the questionnaire, which was qualitative in nature, were analysed by using content analysis of the participants' responses. This was done by identifying the common categories from the participants' responses and grouping them under two sub-themes, namely, (1) challenges encountered in the teaching and learning of physical sciences in rural schools, and (2) factors which supported effective physical sciences teaching and learning in rural schools. These two themes were then grouped under the main theme, namely, pre-service teachers' voices on physical sciences teaching and learning in rural schools.

Results

Following a social constructivist approach, the study explored the environment in which physical sciences learning and teaching operated in rural schools (both negative and positive). The main aim of the questionnaire used in this study was to delve into the challenges and encouraging factors in the effective teaching of physical sciences in rural schools. However, to understand more about the rurality of the participants, the questionnaire also collected some biographical details of the participants, the details of which are given in Table 1:

Table 1 Biographical details of the participants

Location in Eastern Cape	Participant codes
Bizana	PrT 1, PrT 3, PrT 10, PrT 11, PrT 12, PrT 13 and PrT 17
Libode	PrT 4 and PrT 7
Idutywa	PrT 8 and PrT 18
Lusikisiki	PrT 15 and PrT 16
Qumbu	PrT 5
Matatiele	PrT 6
Port St. Johns	PrT 19
Ngqeleni	PrT 9
Qumbu	PrT 5
Mount Frere	PrT 2

It is clear from Table 1 that most of the participants were from Bizana. The mean age of the participants was 24; 16 were between 20 and 25, two were between 26 and 30, and one was between 31 and 35 years old.

Even though both the school and the home environments may contribute to the effective implementation of physical sciences learning and teaching in rural schools, the current study focused only on school factors. The school factors were further divided into three categories: management, teachers, and peers (Figure 1). The major findings are discussed below:

Negative Factors/Challenges Encountered

The challenges identified in the teaching and learning of physical sciences in rural schools are presented below:

School management factors

The extent to which school management offers support in providing a quality school environment is a crucial determinant in the effective teaching and learning of any subject, as is for Physical Sciences. The participants in this study commented on several flaws in the management of rural schools,

which directly affected the effective learning and teaching of physical sciences. These are listed below.

Lack of proper infrastructure

The poor infrastructure acted as a hindrance to effective teaching and learning of physical sciences in rural schools. For example, PrT 17 reported on the poor ventilation of the classrooms and leaking roofs:

> *… the school structure was very poor, broken windows and doors and water on the floor if it was raining …*

Overcrowded classrooms

The majority of the participants complained that they suffered because of the shortage of classrooms and as a result, the existing classrooms were overcrowded. PrT 9 responded as follows:

> *What was bad about my school is that there was shortage in classrooms.*

Shortage of materials

Some of the classrooms did not have enough desks and the learners experienced difficulty in writing while standing. In addition, the learners either had no physical sciences textbooks or the textbooks were insufficient. This limited their opportunities for self-study and restricted them to remembering what the teacher had taught in class. This is illustrated by the responses by PrT 4 and PrT 8 respectively:

> *We were many in Grade 10 and 11 such that we were not using desks. Anyway, we were suffering in writing in the absence of desks.*
>
> *There were no enough textbooks for us to learn or self-study and that made us to be dependent on our class teachers.*

Poor implementation of practical assessment tasks

Laboratory work is one of the most important components of the infrastructure for physical sciences learning and teaching. To check whether the participants had laboratories in their high schools, they were asked a multiple-choice type question which required of them to respond positively or negatively (yes or no). Of the 19 participants from rural backgrounds in the Eastern Cape, only three (15.8%) (PrT 6, PrT 7, and PrT 16) said that they had laboratories at their high schools.

Two follow-up questions (multiple-choice type) were asked to those who had responded that they had laboratory in their schools. The first question required of them to indicate how often they visited the laboratory and the second question required of them to indicate whether the laboratory was equipped with sufficient equipment. All three participants indicated that they visited the labs sometimes and that the laboratories were not fully equipped. It was thus clear that the frequency of lab visits was simply not enough and there was clearly a scarcity of lab equipment.

The vast majority of participants (84.2%) responded that they did not have laboratories at their schools. Those participants who indicated that they did not have laboratories at their schools were required to respond to an open-ended follow-up question in which they were expected to comment on how the practical-based formal assessments were done in the absence of laboratories. It was noted from the participants' responses that when it came to formal school-based assessments, the allocation of marks for the practical assessment tasks was done in various ways in different schools. Some teachers allocated marks without learners actually doing the experiments. The following response by PrT 2 exemplifies this:

> *The practical work that was supposed to be done were converted to assignments and tests. Then we would discuss what we should have done in as class rather conducting experiment and all. So that's how we went on about practical assessment.*

Nine participants pointed out that their teachers demonstrated the experiment in class; the learners were given the necessary information about the experiment and then they had to answer some follow-up questions with their subject teacher's assistance. In some such schools, teachers had to adapt to the limited equipment, and others had to borrow equipment from neighbouring schools (PrT 3). PrT 18 testified that his teachers took the physical sciences learners to the neighbouring school to conduct the practical experiments.

In schools with no equipment at all, teachers converted practical experiment tasks into tests, assignments, or investigatory projects; three participants (PrT 1, PrT 2 & PrT 19) reported on such a practice. In extreme cases teachers would tell the learners that this was supposed to be practical work, and the teacher him/herself would then come up with the expected outcomes (PrT 5).

PrT 11 remarked that they did not do any assessments and did not even have a chance to observe any form of practical experiment. A considerable number of them did not even know how their teachers managed to allocate marks for the practical assessment tasks (PrT 6, PrT 11 & PrT 15).

Corporal punishment

Corporal punishment was reported as a hindrance to effective learning and teaching of physical sciences. This was revealed by PrT 2's comment:

> *… Unfortunately, more beating we had.*

Teacher factors

The participants in this study came up with several dimensions in which their physical sciences teachers failed in performing their roles in an acceptable way. These are presented below.

The complex nature of the subject

Physical Sciences in South African secondary schools is considered a complex subject, which consists of a combination of Physics and Chemistry. Ideally, a physical sciences teacher in South Africa is expected to be equally competent, qualified, and comfortable in both areas of the subject. However, the existing situation in rural schools was found not to be matching the ideal. It was a major challenge for many participants (PrT 7, PrT 13 & PrT 15) who stated that their physical sciences teachers were competent or comfortable in either Physics or Chemistry, but not in both. PrT 7 stated:

> *What was not good about physical science teaching is that the teacher who teaches focussed more on chemistry part of the physical sciences we were suffering on the physics part.*

Lack of qualified physical sciences teachers

The rural schools were found to have a dire shortage of qualified physical sciences teachers. The shortage of teachers mostly affected Grades 10 and 11. The situation in most of the schools was that the learners in Grades 10 and 11 were left without teachers resulting in no topics being taught (PrT 3). Some schools managed the situation by requesting senior learners or learners from neighbouring schools or someone who held a Senior Certificate to teach their learners. PrT 5 responded as follows in this regard:

> *We were taught Physical Sciences by someone who was not a qualified teacher, someone who just passed Grade 12. So he did not have the experience of teaching.*

A better strategy adopted by a few other schools was that they requested the assistance of qualified physical sciences teachers from other schools. I came across a situation where a life sciences teacher was required to teach Physical Sciences. Nevertheless, most Grade 12 learners had qualified, and in some cases, very good physical sciences teachers. PrT 11's response exemplifies some of the observations above:

> *In Grade 10, we never had physics teacher until July. In Grade 11, our biology teacher had to teach us physics because of the shortage of teachers. In Grade 12, I had one of the best physics teachers in our district.*

Teachers' poor content knowledge and/or pedagogic content knowledge

Most of the problems were caused by teachers' lack of content knowledge or pedagogic content knowledge or both. It was reported that the teachers experienced problems with transforming the physical sciences content in a way that was understandable and interesting for the learners. This was evident in the following excerpts (PrT 2 & PrT 13 respectively):

> *The teacher was a main issue; he was unable to define concepts and processes of how certain procedures go about in this subject.*
>
> *The physical sciences teacher was not good at all in subject matter.*

In many cases, it was reported that teachers discouraged their learners from asking questions in the classroom mostly because of the teachers' limited content knowledge (PrT 5, PrT 8 & PrT 10).

The poor teaching methods prevalent in rural physical sciences classrooms retracted from effective learning and teaching of the subject. Teachers mainly focused on explaining concepts, which, in most cases, were poorly understood by learners (PrT 9). Teachers in rural schools failed dismally in employing effective strategies that could arouse interest and motivation among learners. Teachers were found to have used their own preferred teaching methods rather than the appropriate method for a particular topic; these included "reading what is written in the textbooks without any further explanations" (PrT 11 & PrT 12) and "note-giving and explanation of the notes" (PrT 5).

To illustrate the aspect of physical sciences teaching methods employed in the rural classrooms, I asked the participants to recall how they were taught a physical sciences topic, electromagnetic induction, which requires advanced practical investigation or demonstration rather than an explanatory approach. Very few participants (PrT 1 & PrT 2) reported on the former as a learning experience. One participant (PrT 19) reported that the teacher used a model to explain electromagnetism, which gave everyone in the class a clear picture of the concept.

However, a considerable number of learners reported that their teachers had taught this topic by explaining that "like charges repel and unlike charges attract" (PrT 1, PrT 10, PrT 12, PrT 13, PrT 15, PrT 16 & PrT 18) and others by separating electricity and magnetism and explained electromagnetism as a combination of these two concepts (PrT 1 & PrT 14). Some teachers simply provided and explained the notes to learners (PrT 5 & PrT 12). One participant said that she was not taught this topic because they did not have a physical sciences teacher in Grade 11 (PrT 3). Other participants indicated that they were not taught this topic well because of their teachers' lack of content knowledge in this area (PrT 3 & PrT 8).

The above findings point to some of the prevalent physical sciences teaching methods used in rural schools, such as explanation (lecturing), note-giving, reading from textbooks, and so on. Such teacher-centred methods cannot always be considered as appropriate in physical sciences teaching. PrT 3 responded that when the adopted teaching method was teacher-centred, it did not give learners opportunities to engage in active discussion or collaboration:

> *My high school teachers were only using teacher-centred principle. We had no chance to discuss.*

Peer factors

The participants agreed that most of the learners in their schools had a negative attitude towards Physical Sciences. PrT 13 explained as follows:

> *The students in my school were having attitudes towards Physical Sciences. They did not like to do homework and to participate in class.*

Positive Factors

While exploring factors that the participants deemed as demotivating in the teaching and learning of physical sciences in rural schools, I can attest to the fact that it was beneficial to listen to the participants' voices regarding the factors they had identified as supporting effective teaching and learning in a similar context. While the challenges were more or less similar in almost all rural schools, the participants found a few specific instances at their schools as encouraging. The findings are also discussed under the three school factors (Figure 1) below.

School factors

Cooperation among different stakeholders at the school

Many participants reported that the way in which learners, teachers, parents, and principals worked together was something that positively affected the smooth teaching and learning process in their schools. In this regard, PrT 15 responded as follows:

> *What was good is that there was no conflict among teachers, they work hand in hand in order to achieve good results.*

More focus on Mathematics and science subjects

In some schools the teachers and the learners seemed to have understood the importance of spending more time on the critical subjects like Physical Sciences and Mathematics. This was echoed in the following responses (PrT 7 & PrT 8 respectively):

> *My high school was good in Mathematics, there were many mathematics teachers and they teach well maths using extra classes and the results were good.*
>
> *My school was good in Mathematics and other subjects. In fact, our principal was trying all his level best to organise some teachers who did Physical Sciences and I passed it because I like it.*

It was noted from the participants' responses that Mathematics was considered as more important in some schools than any other subject, including Physical Sciences, and that was something that the participants found a motivating factor in their academic experience.

Lack of corporal punishment

Even though corporal punishment is banned in South African schools, it was reported by the participants in this study that it was still practiced in rural schools. The following is one such response (of PrT 2):

> *The teacher was a main issue; he was unable to define concepts and processes of how certain procedures go about in this subject; unfortunately, more beating we had.*

The researcher could hear both sides regarding the practice of corporal punishment: while some participants reported that they were receiving corporal punishment, others claimed that even though there was no form of corporal punishment in their schools, they did not experience any kind of disciplinary problems. However participant PrT 1 pointed out that the lack of corporal punishment when learners did not do their work was something which was not acceptable.

Teacher factors

In general participants appreciated many attributes of their teachers. These are discussed below.

Professional behaviour of teachers

Teachers' professional behaviour included, but was not limited to, punctuality, dedication, hardworking nature (taking extra classes), motivation and reinforcement given to the learners, friendliness, welcoming of questions asked by the learners, patience with learners (repeating the topics when learners found it difficult to grasp concepts), and so on. The following responses (of PrT 9 & PrT 10 respectively) illustrate this:

> *… teachers were doing all they can to give us information although there were classroom shortages.*
>
> *Teachers were friendly to us and were really helping us whenever we need help.*

Some participants accepted that although some teachers struggled with content knowledge of the subject, they were trying their best to teach them well. A considerable number of participants found their teachers' use of past examination question papers for the purpose of practising various topics in Physical Sciences as an effective teaching and learning strategy.

Teachers' pedagogic content knowledge (PCK)

The ability of a teacher to transform physical sciences topics into something which was understandable and interesting for the learners (often referred to as PCK), helped many participants to develop an affinity for the subject. This ability, of course, was found to be related to teachers' subject content knowledge, language/communication skills, the skill of explaining, the skill of using simple and relevant examples, the skill of illustrating with the use of diagrams, the skill of using appropriate practical experiments to help learners in converting abstract scientific concepts to concrete concepts, and so on. Below are a few excerpts (PrT 1 & PrT 4 respectively) which exemplify some of the above

aspects:

> *The physical science teacher was trying so hard to have examples so that learners understand when teaching.*
>
> *Honestly, our teacher was good such that he was motivating us, teaching us properly. In fact, the only way to measure that is the outcome and he was getting good results.*

The above responses are indicative of the skills possessed by rural physical sciences teachers, which inspired their learners to love the subject.

Peer factors

Surprisingly, none of the participants mentioned that their peers had contributed positively to the physical sciences learning and teaching in rural schools.

Discussion

The findings of the study threw light on the current scenario existing in the teaching and learning of physical sciences in rural schools in one of the most disadvantaged provinces of South Africa. While there was a general outcry among participants about the lack of adequate resources (both human and physical) and the quality of existing resources, a considerable number of participants appreciated the way in which the rural schools tried to operate utilising the available resources to meet their expectations.

Even though three categories of environmental factors influenced physical sciences learning in rural schools (management, teacher and peer), the greatest impact was made by either the management or the teacher categories. The participants in the current study expressed their appreciation of a variety of strategies/factors as far as the teaching and learning in a rural environment was concerned. These included, but were not limited to, the way in which different stakeholders of the school worked together, maintaining school discipline without corporal punishment, professional behaviour of teachers – punctuality, dedication, hardworking nature, motivation and reinforcement of learners, the feeling that teachers were approachable, teachers' strong PCK, and the list goes on. Strikingly similar findings were reported by Nkhoma (2002) who explored the classroom practices of Black mathematics teachers. Teachers' willingness to present extra classes, being friendly towards the learners, providing extra resources, being prepared for the class, using practical examples in teaching, being available, motivating learners, having good subject content knowledge and language used in class, are some of the teacher classroom practices which were found to be enabling in mathematics classrooms in South Africa. This shows that, despite many adverse conditions existing in rural schools, some schools and teachers go the extra mile to fight for conditions which facilitate a better academic environment in their schools, despite poor conditions.

While many research studies focus on the challenges and problems experienced in the teaching and learning of physical sciences and/or mathematics in South African schools, the studies that investigated good practices, especially in a rural context and according to what learners have observed and experienced in this regard, are few and far between. In a study that focused on disadvantaged schools which succeed in Mathematics and Science, Malcolm, Keane, Hooloo, Kgaka and Ovens (2000) attest to the fact that learners admire teachers who display good personal qualities and teaching techniques. These include, but are not limited to, good teaching skills, strong subject content knowledge, ability to explain things clearly, and personal qualities like patience, dedication, hard work, and accessibility (Makgato & Mji, 2006).

One of the major drawbacks prevalent in rural schools is the lack of laboratory equipment and poor implementation of practical experiments. Most participants responded by saying that they had never been exposed to a laboratory situation while studying Physical Sciences at high school. This might be because of the alarming, and at the same time common situation, of not having laboratories at most of the rural schools in the province. This resulted in teachers adopting alternative, but in most instances, highly ineffective, strategies to compensate for laboratory experiments. One such strategy was for the teacher to demonstrate part of, or a full experiment, in the classroom and not a laboratory. The demonstration was then followed by asking the learners questions about the demonstration and expecting them to submit some kind of written work to the teacher. This strategy is not as effective as individual or small-group experimentation in a science laboratory in providing the learners with hands-on experience with the equipment. However, teachers are often forced to convert laboratory sessions into demonstrations when the science equipment in the laboratory is not adequate for individual or small-group sessions. Nevertheless, such demonstrations can at least give learners an idea of how the experiments would have been performed in a well-resourced laboratory. Another unfortunate case reported was that the learners copied the required information from their textbooks. However, the fact that laboratory experiments are converted to tests, assignments, or investigatory projects does not facilitate learning. Unfortunately, this was the case for a considerable number of the rural schools at which the participants in this study received their schooling.

Similar findings were reported in a previous study that focused on areas in the rural province of Limpopo, South Africa (Onwu & Stoffels, 2005).

This study focused on science teachers' perspectives on their current classroom practices. Nearly all the teachers participating in this study agreed that practical experiments were performed as teacher demonstrations followed by oral questions posed to the learners. The teachers then handed out self-designed worksheets or those provided in the textbook, and the learners completed them either in class, or as homework, and in groups. Such ineffective teaching and learning methods during practical investigations may result in poor inquiry skills among science learners (Kazeni, Baloyi & Gaigher, 2018). The use of such pedagogical methods were likely to have been influenced by insufficient resources. Clearly, the lack of resources and the poor implementation of practical experiments remain a serious concern in South African schools, especially in rural and disadvantaged areas (Ramnarain & Schuster, 2014).

Many respondents reported that their teachers did not have the necessary skills to deliver physical sciences content in a way that was understandable, interesting, and motivating. This problem could be linked to multiple factors associated with the teachers, but mainly, the complex nature of the subject itself, lack of formal training required to teach the specific subject, and finally, and more importantly, the environment of the school in which they work.

Even though a physical sciences teacher is expected to have the expertise to handle both subject areas (Physics and Chemistry) comfortably, the participants reported that their teachers were not equipped with such expertise. Surprisingly, I could not locate a single study which reported on the difficulty experienced by South African science teachers in handling complex subjects. Such an issue may well not be revealed when the participants are teachers and when the research study does not specifically focus on the challenges encountered in the teaching and learning of complex subjects such as Physical Sciences and Life Sciences. South Africa may be one of a very few countries where teachers are required to teach multiple subjects at high school level. The fact that not all teachers are confident and passionate about teaching two or three subjects should not be ignored.

The lack of qualified teachers, especially in Physical Sciences and Mathematics, has often been reported in South African schools (Makgato & Mji, 2006; Onwu & Stoffels, 2005). Quoting the report released by Education For All (EFA), Makgato and Mji (2006) point out that even though 84% of South African science teachers are professionally qualified, only 42% of science teachers are qualified to teach Physical Sciences. The findings from this study indicate that the situation is even worse in rural schools where other subject teachers, teachers with only a Grade 12 qualification or senior students are assigned to teaching physical sciences. The worst-case scenario is when the learners are left without a physical sciences teacher in the lower grades (Grades 10 & 11), and the schools somehow manage to offer something only when the learners reach Grade 12. The fact that rural schools have been experiencing great difficulty in filling physical sciences teaching positions is something which has often been reported in South Africa. While good teachers are likely to prefer richer, urban schools, the quality of teaching in rural schools is at stake (Van der Berg, 2008). Teacher shortage and underqualified teachers in science, technology, engineering, and mathematics (STEM) subjects is not a concern only in developing countries like South Africa. It was reported by the National Commission on Teaching and America's Future (2002) that student science achievement in rural American schools often suffered as a result of STEM teacher shortage and underqualified teachers. In addition, teacher pedagogy and performance in secondary schools, in particular, have been reported to have drawn some criticism in Tasmania, Australia (Allen, Wright, Cranston, Watson, Beswick & Hay, 2018).

Even though the poor state of resources and infrastructure in South African schools has been consistently reported in many research studies, the status quo remains. The scientific nature of the subject itself demands more resources being made available for schools in these subject than resources required for subjects like Mathematics, languages and Social Sciences (Johnson, Hodges & Monk, 2000). Without enough resources and infrastructure, one cannot expect a teacher to adopt the so-called effective teaching methods in a physical sciences classroom, rather than relying on teacher-centred methods such as lecturing, reading of textbooks, presenting notes, and so on. Rural physical sciences teachers' lack of PCK therefore cannot be viewed in isolation from the poor environment in which these schools are operating.

The lack of resources, which is more prominent in rural schools than in their urban counterparts, restrict learners in rural schools from taking part in out-of-school science activities such as science fairs and exhibitions. In a comparative study of the experiences of rural and urban participants in science fairs in the Limpopo province of South Africa, Mupezeni and Kriek (2018) report that learners in rural schools of the province perform poorly in international science fairs because of the lack of resources and the lack of support from schools and parents. However, one participant in the current study expressed a more serious concern. The participant commented that his/her school was not even interested in sending learners to science exhibitions. It could, therefore, be understood that learners in rural schools either performed poorly in out-of-school science activities or they were not encouraged to participate due to the disadvantaged environment of these schools.

The findings explored in this study present the current environment in which physical sciences teaching and learning takes place in rural schools in one of the most disadvantaged provinces of South Africa. By creating place consciousness among teacher trainees, this study serves as a platform to incorporate critical pedagogy of place in the teacher education curriculum of South African universities in general, and of those which operate in a rural context, in particular. Even though this study specifically focused on how Physical Sciences is implemented in rural schools in South Africa, the findings generated are equally important for any science subjects offered in rural schools around the world. The findings may differ according to cultural and social contexts of different countries. However, the findings of this study reveal the various roles of social elements of the schools (management, teacher and peers) in the effective implementation of physical sciences learning and teaching in rural schools of South Africa. The current situation calls for proactive steps towards uplifting the current science teaching and learning environment in rural schools around the world; this should be done in conjunction with incorporating the aspects of critical pedagogy of place in the preparation of science teachers for rural schools. As Goodpaster, Adedokun and Weaver (2012) attest, preparing creative, innovative science teachers to implement relevant, experiential curricula in rural schools can have a tremendous impact on the educational attainment and STEM aspirations of a nation's rural youth; this in turn, may catalyse the development of scientifically and technologically sound rural communities, which would then promote economic development of a nation.

Conclusion and Recommendations

This paper explored the contexts in which physical sciences teaching and learning take place in rural schools of the Eastern Cape province of South Africa. The results were derived from the voices of teacher trainees currently enrolled for the Bachelor of Education degree programme at a rural-based university in South Africa, by requesting them to reflect on the high schools at which they completed Grade 12. The study adopted an exploratory research method, which was more qualitative in approach; this means that I used more open-ended questions than multiple-choice type questions to delve into details about the participants' physical sciences learning experiences back in their high schools in a rural context. Following a social constructivist approach, the study explored the environment in which rural schools were functioning, focusing on three major aspects – management, teachers and peers, as far as the learning and teaching of physical sciences was concerned. The findings derived from the study are two-fold: challenges experienced and existing best practices. One of the main challenges identified was the lack of resources needed for the schools in general, and for Physical Sciences, in particular. Even though insufficient PCK of teachers who had taught the participants in the rural schools was reported as a major challenge in many schools, I agree with Johnson et al. (2000) who state that when teachers are forced to teach in an environment where no basic resources such as laboratory equipment, textbooks, stationery and so on are available, the available choices and a wide variety of teaching strategies, are often limited. When the environment in which the school is operating is dysfunctional, one cannot expect the teachers to switch their current teaching strategies/approaches to something innovative, which does not fit the current classroom scenario. However, the information generated from this research paper about physical sciences teaching and learning in rural schools can be used to adapt the teacher education curriculum to meet the specific needs of the vast majority of rural communities in South Africa. Moreover, the approach used in this study can be adopted by teacher educators in higher education institutions to generate a place-specific nexus among pre-service teachers regarding the communities they intend to serve; such attempts are necessary in developing a tradition of critical pedagogy of place in the teacher education curricula, both nationally and internationally (Gruenewald, 2003).

The recommendations derived from the findings of this study concentrate mainly on the urgent need to focus the South African Government's attention on improving the environment of rural schools in terms of physical resources. This should be done in conjunction with offering necessary training for rural teachers to boost their confidence and expertise in presenting physical sciences topics, using a wide variety of appropriate teaching approaches. However, training alone, without proper teaching resources, may not result in any constructive difference in the current situation of physical sciences teaching and learning in South African rural schools.

Notes

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