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Abstract. *The outcomes of IEA's Trends in International Mathematics and Science Study (TIMSS) conducted from 1995 to 2002 confirmed that there was no improvement in the learning outcomes of grade eight learners in Mathematics and Science. Additionally, the failure rate in Mathematics at the National Senior Certificate (NSC) Matriculation examination has increased from 2008 to 2018 in South African schools.*

It was consequent on this decline in performance that the South African National Roads Agency Limited (SANRAL) Chair in Science and Mathematics Education developed a short learning intervention programme for Mathematics teachers in South Africa in 2013 and 2014. This research reports post-intervention instructional practices of five teachers at Reitz who took part in the intervention programme. The teachers took part in the training workshops that were organised for participants at the University of the Free State, implemented the knowledge acquired from the programme in their respective schools, and compiled an evidence portfolios of their post-intervention instructional practices. The portfolios of evidence submitted by the teachers were thus analysed to give voice and meaning to their post-intervention instructional practices and reflections. The analyses provide evidences of which aspects of their instructional delivery worked well while other aspects did not work well.

Keywords: *evidence portfolios, instructional practices, science education, short learning intervention programme, second-ary school teachers*

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INSTRUCTIONAL PRACTICES OF SCIENCE TEACHERS IN RURAL LEARNING ECOLOGIES

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Introduction

The inadequacies of the teachers training programmes to prepare teachers for the challenges inherent in the teaching profession have caused teachers' continuing professional development to gain momentum in most countries of the world. The dynamic nature of the school climate, teaching strategies, learners' characteristics, and management style have led teachers to seek alternate means to update their content knowledge and teaching skills to remain relevant in globalised schools. Teachers continuing professional development have received increased attention in different countries of the world (Mokhele & Jita, 2010). The position of Mokhele and Jita (2010) relates to the realisation of varied stakeholders that sustained development of teachers most especially in Mathematics, could potentially change the instructional practices of teachers to globally acceptable quality. Christiansen and Bertram (2019) stated that numerous societies believe that schools should equip learners with basic numeracy and literacy skills that are discipline-relevant, to enable them get jobs and become critical thinkers as well as problem solvers, in order to fully participate in negotiated democratic institutions.

Venkat and Spaul (2015) reported that numerous assessment data pointed to poor performance in Mathematics at different school levels in South Africa. This has led to the South African National Roads Agency Limited (SANRAL) Chair in Science and Mathematics Education to develop a cluster of training workshops for Mathematics teachers in South Africa. The five teachers whose instructional practices are reported in this article were part of a cohort that participated in the continuous professional development programmes that took place at the University of the Free State. This article presents the post-instructional practices of the five teachers that underwent the short learning intervention programme implemented by SANRAL Chair.

'Reitz' which started in 1889 was named after Francis Reitz who was the former Premier of the Free State. This State is a town in the Thabo Mofutsanyana district. The town is located fifty-eight kilometres from Frankfort and fifty kilometres from Bethlehem. The inhabitants of Reitz thrive on maize, wheat and cattle farming (<https://www.free-state-info.co.za/provinces/town/463/reitz>). Reitz is part of Nketoana local municipality that is administered by Thabo Mofutsanyana district. Nketoana is a category B municipality which is

the second smallest of the six municipalities in the district. It makes up seventeen percent of the Thabo Mofutsanyana district. The major drainage system in Nketoana municipality which administers Reitz passes through Reitz or Petrus Steyn and is called 'Nketoana' (<https://municipalities.co.za/overview/1052/nketoana-local-municipality>). The five Mathematics teachers from Reitz were invited for the short learning intervention programme at the University of the Free State, to enable them update their mathematical knowledge and teaching skills. This is because of decline in learners Mathematics performance which seriously affects the learners in rural schools in South Africa. The Municipal Demarcation Board (2018) reported that there are 60, 324 residents at Nketoana municipality with highest population density found in the Reitz/Petsana area.

Research Problem

Scholars have divergent opinions on the factors that are responsible for the decline in Mathematics and Science performance of learners in South Africa. This research aims to unravel the factors that are responsible for this decline. Mji and Makgato (2006) unveiled a fundamental cause of under-achievement in Science and Mathematics in South Africa with the outcomes of the 1995's Third International Mathematics and Science Study (TIMSS) in which the country was rated the least among the forty-one countries that participated. The poor performances of learners in mathematics and other science subjects were attributed to different factors that are related to rudimentary pedagogical approaches. Tachie and Molepo (2019) asserted that teachers must adopt varied teaching strategies and skills to foster mathematics learning to promote learners' mathematical reasoning rather memorizing mathematical facts. Tachie and Molepo (2019) supported Web and Austin's (2009) position on the poor performance of learners in Mathematics in South Africa. While we agree with Tachie and Molepo's (2019) position that the practices of teachers should influence learners' mastery of mathematical concepts and acquisition of problem-solving skills, the dearth of instructors' meta-cognitive skills in rural schools makes it difficult for teachers to be agents of this desired transformations.

Tayyaba (2011) reflected on the rural-urban gaps in students' reading achievement and stated that a growing body of scholarly investigations revealed mixed and inconsistent trends of findings on the disparities in academic performance of learners from rural and urban backgrounds. Asare and Siaw (2015) highlighted factors affecting students' academic performance in rural or urban high schools as: school culture or climate, language of instruction, strategies and methods of teaching, class size, and students' background. These factors manifest in different forms in both rural and urban schools. Zhang (2006) reiterated these challenges of rural education by affirming that rurality is synonymous with disadvantages for learning in Sub-Saharan Africa. Zhang (2006) went on to state that learners in urban areas marginally outperformed their rural counterparts in Sub-Saharan Africa. However, Zhang (2006) stated that there were no gender differences in the reading achievement of selected primary school pupils in Sub-Saharan Africa. It is observable from the positions of Tayyaba (2011), Tachie and Molepo (2019), Opoku-Asare and Siaw (2015), and Zhang (2006) that teachers are the 'drivers' of any meaningful process that fosters learners' mathematical literacy, while learners are at the centre of mathematics learning.

The information provided by Reddy et al. (2012) on the poor performance of South Africa, Botswana, and Honduras in TIMSS 2011 prompted scholars such as Jita and Ige (2019) to issue a clarion call to researchers to design intervention programmes for mathematics and science teachers in South Africa. It was consequent on the poor performance of learners in Science and Mathematics in South Africa that this research presents the outcomes of the intervention programme carried out by the South African National Roads Agency Limited (SANRAL) Chair in Science and Mathematics Education at University of the Free State, to retrain science teachers in grades 1 to 9 in learning ecologies in South Africa. This research explicated information beyond the notion of 'school location' (i.e. rural schools) which has been solely identified by several researchers as the cause of students' under-achievement in Mathematics and science related disciplines.

Theoretical Framework

This research was underpinned by peer observation theory of learning. Donnelly (2007) posited that despite the application of peer observation of teaching in a variety of teaching-learning contexts, it is applicable in educational programme development as a reflective device for emerging teachers' individual portfolio. Figure 1 illustrates the peer observation cycle designed by Manchester Metropolitan University Teaching Academy (2019).



Figure 1*Peer observation cycle*

Figure 1 is sub-divided into these steps: meet the observee to identify objectives, observe the session (or other activity), discuss aspects of interest, adapt and plan ideas for own practice, and report gains in a professional development review. The steps presented by Manchester Metropolitan University Teaching Academy (2019) are aimed at reconnecting teaching to disciplines which are basis of intellectual disciplines (See Shulman, 1993). Shulman (1993) affirmed that to fully achieve the objectives of peer observation, the evaluations should have positive consequences for the processes and persons evaluated. Siddiqui et al. (2007) affirmed that there are several models of peer observation teaching which are classified based on the number of observers or the aim of the observation. The peer observation model is relevant to this research because the selected Mathematics teachers met and discussed the objectives of their lessons and set ground rules. These teachers collaboratively observed the lessons presented by each of them, and formally had group discussions to discuss aspects that were of interest to each reviewer (i.e. observing teachers). The outcomes of these group reviews empowered each teacher to adapt and plan ideas for their teaching practices. The adaptation and planning by teachers emanated from reflection, which Valdman et al. (2017) affirmed as fundamental for the effectiveness of continuous professional development in assisting teachers to reflect on their change beliefs. The benefits each teacher derived were reported in the portfolios of evidence that were submitted to the Research Office of SANRAL Chair in Science and Mathematics Education at the University of the Free State. This question *“What are the pre-instructional practices, instructional practices, and post-instructional reflections of the selected teachers after the intervention programme?”* was answered in this research.

The SANRAL Chair in Science and Mathematics Education Short Learning Intervention Programme

The Intervention Programme is founded on Bell’s (2002) Peer Observation Model and Shulman’s (1987) Model of Pedagogical Reasoning and Action. Bell (2012) stated that the peer observation process encouraged tutors to specifically consider good practices of teaching from the student’s perspective. In this research, the model enabled

teachers to specifically consider ideal practices of teaching from their peers' perspectives to improve instructional delivery in their schools. The Bell's 2002 cyclical model comprises pre-observation, observation, post-observation feedback, and reflection. The benefits of these four-pronged processes according to Bell and Mladenovic (2008) are its academic development potentials and the improvements offer teaching practice and development of confidence by teachers. The Bell's (2002) became substantial in the development of the SANRAL's Short Learning Intervention Programme because it enabled teachers to develop confidence in the post-intervention teaching activities and improve their teaching practices in Mathematics.

However, Bell and Mladenovic (2008) cautioned that there can be negative aspects of peer observation that could potentially prevent teachers from engaging in it. Bell (2005) highlighted these negative aspects as challenging because they involve written critical reflection, successful and unsuccessful exploration experiences of teaching, as well as provision and acceptance of feedback. It is expedient to point out that these challenging aspects highlighted by Bell and Mladenovic (2008) and Bell (2005) are the key factors that determined the success of the post-intervention teaching of Insulators and Conductors, Uses of Water and Resources of Water, Feeding habits of animals, Colours, and Living Organisms by teachers that participated in the SANRAL's programme. The portfolio of evidences put together by these teachers are practically inconclusive without implementing these challenging aspects. Therefore, this research answered the aims to present the changes that features in the pre-instructional preparation, instructional practices, and post-instructional reflections of five teachers in rural schools in Reitz that participated in the the SANRAL's intervention programme. These observed changes were discussed to enable science teachers identify the best practices in teaching mathematics and sciences in rural schools.

Research Methodology

General Background

The research adopted the 'ex post facto' design of qualitative type. The data utilized to answer the research questions were drawn from the 'portfolios of evidence' turned in by the selected Mathematics teachers who underwent the SANRAL Chair in Science and Mathematics' Short Learning Intervention Programme. The data could not also be altered or manipulated thus this research qualifies as an 'ex post facto'.

Design of Short Learning Intervention Programme for Mathematics Teachers

The Intervention Programme was developed to enhance teachers' knowledge of Science and Mathematics teaching in grades 1 to 9 in learning ecologies in South Africa. The Science and Mathematics Knowledge for Teaching (SMKT) included Common Content Knowledge (CCK), Specialised Content Knowledge (SCK), Knowledge of Contents and Students (KCS), and Knowledge of Content and Teaching (KCT). There was a formal involvement of schools in which the selected teachers worked in their recruitment for the Intervention Programme to ensure the teachers completed training programme and implemented it in their respective schools.

The selected five teachers were exposed to professional development workshops, independent tasks, group tasks, and group teach-in on science problems of Insulators and Conductors, uses of water and resources of water, feeding habits of animals, colours, and living organisms, during the workshops. The data generated by these five teachers were presented because of their professional affiliation to rural schools.

Participants

Five teachers that taught natural sciences, life skills, and social sciences at intermediate schools in Reitz were purposefully selected for this research. These teachers were part of 125 Science and Mathematics teachers that were selected from sixty of the one hundred and twenty schools in Free State province and re-trained at the SANRAL Chair in Science and Mathematics' Short Learning Intervention Programme. The teachers were purposefully selected because they participated in the above programme, constituted a lesson study group at Reitz, put to use the knowledge acquired from the Intervention Programme, and submitted the portfolio of evidence attesting to their post-intervention instructional practices. These teachers were trained during the Intervention workshops that took place on 15th – 16th 2013, 7th – 8th February 2014, and 7th – 8th March 2014 at the University of the Free State. The data collected during these intervention workshops have become a veritable source of information to



enable educational researchers initiate fresh efforts to retrain science and mathematics teachers in South Africa, consequent on minimal improvements reported in learners' science and mathematics attainment by TIMSS in the previous twenty years.

Instrument and Procedures

The 'Lesson Study: individual Reports' that was designed by the Intervention Programme provider has these sections: formation of the lesson study groups; action activities, lesson study and challenges and prospects. The design of the 'Lesson Study: individual Reports' was consistent with Bell (2002)'s model of peer observation which are pre-observation, post-observation feedback, and reflection.

Another instrument that was used in this research was the 'Science and Mathematical Knowledge for Teaching UFS Short Learning Programme (SMKTUSLP)'. This instrument provided the details of the Intervention Programme, and the expectations of the intervention provider from the selected teachers. Section A of the second instrument provided the details of sponsor of the Programme. Section B presented the expectations of the intervention provider from the selected teachers such as commitment and responsibility, active participation in training workshops, and implementation of post-intervention instruction in the teachers' schools of affiliation. Section C of the instrument provided information on the administration and logistics of the training workshops that were held at the Bloemfontein Campus of University of the Free State.

In addition to these, the 'Lesson Study Observational Form' was developed by the SANRAL Chair in Science and Mathematics Education for the trainees to carry out a peer observation of their instructional delivery after undergoing the intervention. The 'LSOF' was vetted by researchers in SANRAL Chair in Science and Mathematics Education to determine its appropriateness for evaluating Mathematics lessons. Each lesson study group was given the 'LSOF' to determine time in minutes for each lesson, describe what the teacher was doing and/or saying, and describe what the learners were doing and/or saying. The feedbacks provided by the selected five Mathematics teachers at Reitz were included in the 'Portfolio of Evidence' provided by these teachers.

Credibility and Trustworthiness

The instruments used for the collection of data were produced by the SANRAL Chair in Science and Mathematics Education at the University of the Free State. The Professor has more than twenty years of teaching and research experience in Mathematics. The LSIR and MKTUSLP were vetted by the Free State Department of Education (FSDoE), and Education, Training and Development Practices Sector Education and Training Authority (ETDP-SETA) for evaluation and amendments. These government agencies confirmed the consistency of the research instruments with the guidelines stipulated in government policy documents on teachers' professional development in Mathematics Education. The feedback of these government agencies proved substantial to the improvement of the research instruments.

Implementation of Post-Intervention Instructional Delivery of the Science Concepts

The selected teachers collaboratively observed each post-intervention instructional delivery and filled in their comments on the Lesson Study Observational Form. The teachers generated data during the post-instructional reflections on what worked well, what did not work well, what should be changed, and what challenges were observed during the lesson presentations. These qualitative data were included in the 'Portfolio of Evidence' submitted by the teachers.

The teachers constituted a participatory lesson study group at Reitz in Nketoana Municipality. These teachers collaboratively planned three lessons on the science concepts of insulators and conductors, uses of water and resources of water, feeding habits of animals, colours, and living organisms. The teachers presented the three lessons, collaboratively observed the lessons presented by each teacher by checking a rating form, reviewed the lessons, and made available the reviews to the instructional teacher. The details of the post-intervention instructional deliveries were submitted to the intervention provider as 'Portfolio of Evidence' at the University of the Free State. The selected teachers reported again to the School Governing Board when necessary.

The teachers formally had a meeting at the office of the principal in one of the selected schools and agreed on modalities for administering the lesson study group. They also met on agreed periods to operationally design



teaching strategies they would adopt to teach the science concepts of insulators and conductors, uses of water and resources of water, feeding habits of animals, colours, and living organisms from knowledge acquired at the intervention workshops that took place at University of the Free State. These teachers created instructional materials and prepared the lesson plans on insulators and conductors, uses of water and resources of water, feeding habits of animals, colours, and living organisms. Each teacher presented a lesson for an hour on weekly basis while the other teachers evaluated the lessons with the instruments provided by the SANRAL Chair in Science and Mathematics. The selected teachers met after the teaching periods had been concluded, reviewed the feedbacks on each implemented lesson, and designed the 'Portfolio of Evidence' which was submitted to SANRAL Chair in Science and Mathematics Education.

Data Analysis

The portfolios of evidence submitted were analysed to give voice and meaning to the pre-instructional practices, instructional practices, and post-instructional reflections of the selected five teachers after they had participated in the SANRAL Chair in Science and Mathematics' Short Learning Intervention Programme. The data contents of the portfolio of evidence were thematically arranged based on pre-instructional practices, instructional practices, and post-instructional reflections of each teacher, and open coded to identify emerging themes in the teachers' post-intervention practices. In order to maintain the confidentiality of the selected five teachers, any identifier such as schools, class, names, names of advisors/principals were given pseudo-identities. These codes and emergent themes are presented in the research results and discussion sections.

Ethical Considerations

The SANRAL Chair in Science and Mathematics' Short Learning Intervention Programme was submitted to the Ethics Committee at the University of the Free State for review, after which it was approved. The selected teachers further provided informed consent and were made to sign a contract with the schools that nominated them for the Intervention Programme to complete the Programme to enable them train other Science teachers at the nominating schools. The researchers created avenues for the selected teachers to discontinue at any point in the Programme (which will lead to inability of teachers that failed to complete the programme to train other teachers at their schools).

Research Results

In order to establish how the selected teachers utilized the knowledge acquired from the SANRAL Chair in Science and Mathematics' Short Learning Intervention Programme to teach the science concepts of insulators and conductors, uses of water and resources of water, feeding habits of animals, colours, and living organisms, the data in the portfolio of evidence were thematically analysed on pre-instructional practices, the instructional practices, and post-instructional reflections of the selected teachers. The data in each teacher's portfolio were repeatedly compared to ascertain the themes that emerged from their lesson study group.

The information on Table 1 shows the pre-instructional practice of teacher A (Mrs. Nyambose) after undergoing the Intervention Programme.

Table 1

Pre-instructional Preparations of Teacher A

Date	05.09.12
Place/School	Petsana Intermediate School
Time	11h30 – 12h20 (50minutes)
Name of All Participating Teachers	Mr Motsa L.P., Mr. Sello, Mrs. Dihla M.M., Miss Nkanga, L.J., and Miss Nyamu M.



Date	05.09.12
Implementing Teacher	Mrs. Moshoe, N.M.
Facilitator/Group Leader	Mrs. Moshoe, N.M.
Class	Grade 6C
Subject	Natural Sciences
Topic Selected for the Lesson	Insulators and Conductors – Grade 6c
Prior Knowledge of the students	Remedial work on draw and interpret circuit diagrams
Intended Outcomes	Learners must be able to identify insulators and conductors – Not all objects conduct electricity.
Content to be covered	Objects that are made of metal all conducted electricity. We say metals are electrical conductors. Objects that are not made of metals – (non-metal) are insulators.
Resources	Nails, metal teaspoon, plastic, connectors, teaspoon, bulb, paper dip, cells, pencil.
Lesson activities	<ol style="list-style-type: none"> 1. Predict which will light the bulb when connected in a circuit 2. Investigate which are conductors 3. Record their observation 4. Conclude
Assessment Activities	Compare their predictions with the recorded observation. Homework: Worksheet on classification of objects as insulators and conductors.
Advisor (Subject advisor/external expert)	
Report writing	

Table 1 shows that Teacher A spent fifty-minutes to teach the science topic of 'Insulators and Conductors' to Grade six learners. Five teachers participated in the lesson study group discussion, but only three teachers monitored the lesson to provide constructive feedbacks. It is evident from the documents analysed that Teacher A used scientific approach to evaluate what the learners knew about 'Insulators and Conductors' by carrying out a remedial work on drawing and interpretation of circuit diagrams. The teacher used a behavioural word 'identify' which falls in the domain of 'remembering' in Bloom's taxonomy of educational objectives (Anderson et al., 2000). The teacher used teaching resources that are real to enable students 'remember' facts on 'Insulators and Conductors'. Other behavioural words that were used during the lesson activities are 'predict', 'investigate', 'record', and 'conclude', and ensured the students compared their predictions with recorded scientific observations. One high point in the lesson delivery is the 'Homework' handed to the learners on classification of objects as insulators and conductors which must be turned on a worksheet created by Teacher A. It is a high point because the homework enabled the learners to construct independent knowledge on how they understood the concepts of 'Insulators and Conductors' taught by Teacher A.

Table 2*Lesson Study Observational Form for Teacher A*

Duration	Description of teacher's activity	Description of learners' activities
Teacher A	The educators asked learners to identify insulators and conductors of electricity	Learners classify insulators and conductors of electricity respectively.



Duration	Description of teacher's activity	Description of learners' activities
	The educator tested using apparatus if the electric current is present or flowing.	Learners are requested to conduct an experiment to test if there is current flowing when using insulators or conductors of electricity.
	The educator used different materials and asked learners to name different materials. She writes materials which are insulators and conductors.	Learners are able to identify materials which are insulators and conductors e.g. paper dip-conductor of electricity but a plastic is an insulator.
	The educator grouped learners to write insulators and conductors of electricity respectively.	Learners wrote insulators and conductors of electricity in their flip charts and answers were corrected by the educator together with learners.
Teacher B	The teacher asks learners to predict which objects and insulators and which are conductors.	In groups, learners classify the insulators and the conductors.
	The educator tested using apparatus, whether electric current is present or flowing	Learners did the experiment to test if there was current flowing using insulator or conductors of electricity
	Ask learners to classify insulators and conductors	Answer questions
	Check whether the learners have predicted correctly	They check other groups' answers
	Ask learners to write the activity in their activity books.	They write the activity.
Teacher C 11h00	The teacher asked the learners to predict the resources	The learners listened to the teacher then they predict resources which are insulators, and which are conductors and they write them on the flip charts.
	Then the teacher wrote the resources that have light and those which do not have light.	Learners tested each resource that have light and those that do not have light.
		Learners were then given assessment to write on the worksheet.
	The educator together with the learners were actively involved in the lesson. -Questions were asked learners and learners were able to answer those questions. -Different apparatus were used to demonstrate the lesson to learners.	Learners were actively involved in the lesson. -They showed the pre-knowledge. Most of them participated very well. - Learners were given a chance to use the apparatus Insulator: Others had the background.

Regarding the instructional practices of Teacher A, the observing teachers affirmed that Teacher A asked the learners to 'predict' rather than 'identify' as stated in his/her lesson plan. For instance, the observing Teacher 1B stated that:

'The teacher asks learners to predict which objects and insulators and which are conductors. Learners wrote insulators and conductors of electricity in their flip charts and answers were corrected by the educator together with learners'

While observing Teacher 1C affirmed that:

'The teacher asked the learners to predict the resources. The learners listened to the teacher, then they predicted resources which are insulators, and which are conductors and they wrote them on the flip charts.'

The data on the 'Lesson Study Observational Form' shows that Teacher A used different scientific apparatus to demonstrate the concepts of insulators and conductors to the Grade 6 learners. Teacher 1A stated that:



"The educator grouped learners to write insulators and conductors of electricity respectively. Learners wrote insulators and conductors of electricity in their flip charts and answers were corrected by the educator together with learners."

Teacher 1C described the use of apparatus by Teacher A as follows:

"The educator together with the learners were actively involved in the lesson. -Questions were asked learners and learners were able to answer those questions. - Different apparatus were used to demonstrate the lesson to learners."

Table 3

Post Instructional Reflections of Teacher A

	General Observations	Lesson Evaluation	Changes	Challenges
Implementing Teacher	The lesson went well because learners were actively involved and at the end they could state insulators and conductors	The one group was confused they could not correctly identify insulators and conductors.	Explanation of what insulator and what conductors are should be given to learners rather than the self-discovery method	A limited number of resources used for experiment. Each group should have its own set of apparatus.
Observing Teachers	Learners were actively involved throughout the lesson- answering of questions, prediction, observation as one learner performed the experiment	Limited resources. It will be better if each group had its resources and conduct the experiment	Make resources available for each group. Self-discovery for grade 6 is too high for them. Explain clearly to learners the concept of insulators and conductors	Too many learners in a class; limited resources for different groups.
		The teacher must lead the learners e.g. Explain the meaning of the words: insulators and conductors. Self-discovery is a little bit higher for their standard. That is why the other group could not understand the differences of the materials.		
	The teacher was well resourced because she knew what would be needed or used when teaching insulators and conductors	The teacher did not explain the two terms because other learners have learnt this from grades.	Availability of enough resources where each group will conduct its experiment rather than observing one learner performing.	The teacher must explain first the terms so that the learners can be able to sort the insulators and conductors.
		-The educator must explain to learners the meaning of insulator & conductor. -The method of self-discovery was too high; learners couldn't understand.		

During the post-instructional reflections, it was evident from the teachers' discussion that the teaching strategy adopted by Teacher A did not turn out well as envisaged by the lesson study group. Observing Teacher 1A attested to this observation made by other group members and commented that:

"Learners were actively involved throughout the lesson answering of questions, prediction, observation as one learner performed the experiment. Limited resources. It will be better if each group had its resources and conduct the experiment. Make resources available for each group. Self-discovery for Grade 6 is too high for them. Explain clearly to learners about the concept of insulators and conductors."



Observing Teacher 1B declared weaknesses of the self-discovery teaching strategy adopted by Teacher A, and stated that:

“The teacher must lead the learners e.g. Explain the meaning of the words insulators and conductors. Self-discovery is a little bit higher for their standard. That is why the other could not understand the differences of the materials.”

Observing Teacher 1C also affirmed the shortcomings of the teacher strategy adopted by Teacher A as follows:

“The educator must explain to learners the meaning of insulator & conductor. The method of self-discovery was too high learners couldn’t understand.”

Table 4

Pre-instructional Practice of Teacher A (Second Lesson)

Date	16.01.2013
Place/School	Petsana Primary School
Time	08h00 – 09h00 (60minutes)
Name of All Participating Teachers	Miss Nkanga, Mr Martin, Miss Nyamu
Implementing Teacher	Mrs. Moshoe
Facilitator/Group Leader	Mrs. Moshoe
Class	6
Subject	Natural Science
Topic Selected for the Lesson	Living Organism Characteristics of Living Organisms
Prior Knowledge of the students	Naming all living things around them.
Intended Outcomes	Life process (seven characteristics) Why plants are living organisms?
Content to be covered	Plant’s roots grow down-movement Plants grow from seeds-reproduce Plants grow towards the light sensitivity Plants make their own food – Feeding Plant release oxygen – excretion Plants use carbon dioxide – respiration Seedling grow into new plants – growth
Resources	Flip- charts, Worksheet
Lesson activities	Round – robin Presentation – by learners
Assessment Activities	Worksheet to be completed by learners as classwork.
Advisor (Subject advisor/external expert)	
Report writing	



The second lesson was taught by Teacher A to Grade 6 learners and lasted for sixty minutes. It was observed by three teachers in the lesson study group. The lesson focused on 'Living Organisms' and proposed flip charts and worksheet as instructional resources. The teacher adopted 'Round-robin presentation' by learners for the presentation of lesson activities.

Table 5

Lesson Study Observations for Teacher A's Second Lesson (Tech Natural Science, Grade 6)

Duration	Description of teacher's activity	Description of learners' activities
Teacher A 5min	Instruction given to learner to write names of living things they know (Round Robin activity).	Learners were given a chance to write names of living things without repeating the names of those living things.
10min	Classification of names of living things as plants and animals (names that were written above)	Learners classified names as plants and animals from the names written above.
10min	Learners are to give reasons why plants are classified as living things.	Learners wrote down their reasons on their flip chart on why plants are classified as living organisms (things).
10min	A presenter will present the group's work to all members of a class. 5mins are allowed for presentations.	Learner presented the work to the class and questions were asked by other learners.
20-25min	Teacher distributed worksheet in a form of assessment activity.	Learners did the work individually.
Teacher B 5min	The teacher gave instruction to write all living things they know in their groups on the flip chart.	Learners wrote names of all living things they knew.
10min	Learners were instructed to classify the names written above as plants and animals.	Learners classified the names of living things as plants and Animals.
10min	Learners were to write the reasons why they say plants are living organisms.	Learners wrote reasons in their flip charts.
10min	One learner represented the group's work that was on the flip chart. 5min to present and question to be answered by presenter or group members.	Learners listened carefully to the presenter and were allowed to ask questions after presentations.
20-25min	Teacher distributed worksheets to learners to do Assessment activity.	Learners worked individually.

The lesson observational form attested to the time management that Teacher A brought to bear on the presentation of the lesson as period ranging from 5minutes, 10minutes, 20minutes, to 25minutes were distributed for each aspect of the lesson. Group learning that might have emanated from the 'Round Robin' activities adopted by the teacher are evident in the lesson presentation. Teacher B attested to the group nature of the activities carried out by the learners, and stated that:

"One learner represented the group's work that is on the flip-chart. 5mins to present and question to be answered by presenter or group members. Learners listened carefully to the presenter and were allowed to ask questions after presentations."



Table 6*Post Instructional Reflections of Teacher A's Second Lesson*

	General Observations	Lesson Evaluation	Changes	Challenges
Implementing Teacher	Learners were able to write names of living things, approximately 20. They were able to classify them as plants and animals because there was a link between Grade 5 work.	They could not confidently give reasons as they were doing the presentations. Learners were not exposed to the method of presentation in their previous class.	Learners should be given more chance to express themselves to air their views. There should be a two-way communication.	Learners could not express themselves confidently and they could not respond to some questions from other learners. Overcrowding is a contributing factor to my teaching.
Observing Teachers	Learners were actively involved from the beginning of the period until the end of it.	Learners were not confident with their presentation. Teacher needs to expose them more on doing presentation. Meet with English teacher on how to train learner so as to speak correct English and with confidence.	Groups are too big as numbers of each group are large. We need to have a manageable size of the groups.	Learners need to be exposed more to reasoning type of question in their previous class. The teacher expected too much from them.
	Learners were participating well and enjoyed the lesson. They were given chance to participate.	Learners could not reason why? Plants are living things with confidence.	The teacher should meet with the English teacher to help in training learners in public speaking.	Overcrowding of classes. This led to a problem of the teacher not being able to give attention to all learners.

During the post-instructional reflections of the lesson study group, Teacher A reflected on the lesson and commented that:

"They (Learners) could not confidently give reasons as they were doing the presentations. Learners were not exposed to the method of presentation in their previous class. Learners could not express themselves confidently and they could not respond to some questions from other learners. Overcrowding is a contributing factor to my teaching.

The reflection of Teacher A was complemented by an observing teacher who stated that:

"Learners were not confident with their presentation. Teacher needs to expose them more to doing presentations. Meet with English teacher on how to train learner so as to speak correct English and with confidence. Learners need to be exposed more to reasoning type of question in their previous class. The teacher expected too much from them (Teacher A)."

Observing Teacher B affirmed the challenges inherent in Teacher A's presentation of the lesson and passionately commented thus:

"Learners could not reason why Plants are living things with confidence. The teacher should meet with the English teacher to help in training learners in public speaking. Overcrowding of classes. This led to a problem of the teacher not being able to give attention to all learners."

From explanations of Teacher A and the observing teachers, the benefits of the SANRAL Chair in Science and Mathematics' Short Learning Intervention Programme they underwent was evident in the Teacher A's sequencing of his/her instructional delivery, the use of appropriate teaching resources, and the adoption of a scientific instructional strategy (i.e. self-discovery) even though it proved inconsequential. The themes that emerged from these lesson study group discourses are group learning, overcrowded science classrooms, English-Science teacher collaboration, homework versus classwork. The implication of these emerging themes would be exhaustively examined in the discussion section.



Table 7*Pre-instructional Plan of Teacher B*

Date	24.10.12
Place/School	Petsana Intermediate School
Time	09h00 – 09h30 (30minutes)
Name of All Participating Teachers	L.J. Nkanga, M.M. Dihla, M.M. Annah, Moshoe, N.M.
Implementing Teacher	Ms. Nyamu, E.M.
Facilitator/Group Leader	Mrs. Moshoe, N.M.
Class	Grade 4D
Subject	Social Science
Topic Selected for the Lesson	Uses of Water and Resources of Water
Prior Knowledge of the students	Resources: Identify places where water is obtained.
Intended Outcomes	How to use water and importance of saving water.
Content to be covered	Social Science 1. Use of water daily. 2. Importance of water management
Resources	Pictures
Lesson activities	Revision on sources of water Uses of water and estimated amount of use
Assessment Activities	Identify the uses of water in pictures the amount of water used.
Advisor (Subject advisor/external expert)	
Report writing	

Table 7 presents the information regarding another instructional delivery which was presented for 30minutes to Grade 4 learners on 'Uses of Water and Resources of Water'. The teacher taught learners how to use water and importance of saving water. Four teachers observed the implementing teacher during this instructional delivery. Behavioural words such as 'Revision' and 'Identify' were proposed by the teacher to bring the learners into the lesson.

Table 8*Lesson Study Observations for Teacher B (Social Science)*

Duration	Description of teacher's activity	Description of learners' activities
Teacher A	Questions were asked by the teacher based on sources of water.	Learners were able to answer questions.
	Identification of sources: lake, dam, ocean, borehole, windmill	Learners were able to identify the sources of water correctly.
	Demonstration of uses of water, drinking, swimming, cooking	Learners were able to dramatize uses of water.
	Worksheet was given to the learners	Learners were filling in answers
Teacher B	Questions were asked based on water – uses and sources of water	Answering of questions. Individual questions based on the resources



Duration	Description of teacher's activity	Description of learners' activities
	Identify the sources of lakes, dams, ocean, borehole	Water usage. Determine whether it is clean water or dirty water
	Windmill	
	Practical demonstration on uses, drinking, swimming	
	Activity – Worksheet	Worksheet – Questions were to be answered by learners.
Teacher C	The teacher asked learners questions about water (importance of water)	Learners answered questions orally.
10mins	The teacher explained the uses of water (bathing, cooking, drinking, watering plants (demonstration))	The learners indicated to educator on water wastage or correct usage of it.
10mins	A worksheet was distributed to learners by educator on uses of water	The learners were to describe the pictures on the worksheet on uses of water.
10mins	Worksheet were used as notes by learners	Learners were expected to study the notes on uses and resources of water.
Teacher D	Questions were asked by the teacher based on sources 'places where we find water'.	Learners were able to answer the questions.
	Identification of sources Lake, dam, Ocean, borehole, Windmill	Sources were correctly identified
	Practical demonstration of uses of water: drinking, swimming, toilet use	Bottled water was given to learners
	Worksheet on identification	Learners were expected to write answers on the worksheets.

The teachers that observed the lesson reported practical demonstrations, dramatization of uses of water, and use of worksheets as notes by learners as the high points of this lesson. A teacher commented that on a lesson that was done for 10mins:

"The teacher asked learners questions about water (importance of water). The teacher explained the uses of water (bathing, cooking, drinking, watering plants (demonstration)). worksheets were distributed to learners by educator on uses of water. Worksheets were used as notes to learners" Teacher 2c.

From the documents analysed and comments of the observing teachers, practical scientific demonstrations and use of worksheets for class activities are the emerging instructional practices in the lesson taught by Teacher B.

Table 9

Pre-instructional Plan of Teacher C

Date	11.01.2013
Place/School	Petsana Intermediate School
Time	11h00 – 12h00 (60minutes)
Name of All Participating Teachers	Miss Nkanga, Mrs. Annah, Miss Nyamu, Mrs. Moshoe, Mr. Martin
Implementing Teacher	Mme. Dihla M.M. (Grade 3)
Facilitator/Group Leader	Mrs. Moshoe, N.M.



Class	Grade 3
Subject	Life Skills
Topic Selected for the Lesson	Carnivores Herbivores - Feeding habits of animals Omnivores
Prior Knowledge of the students	- Animals that they know domestic animals, cats, dogs, cow, sheep, chicken.
Intended Outcomes	Learners must know the feeding habits of animals.
Content to be covered	Animals have different feeding styles. Animals that feed on meat only are called carnivores. Animals that feed on plants only are called herbivores. Animals that feed on both plants and animals are called omnivores.
Resources	Pictures of animals
Lesson activities	Learners identify the animals that feed on plants (meat) or both. Carnivores, Herbivores, Omnivores, new words
Assessment Activities	Pictures of wild animals are included with domestic animals. They should classify them according to feeding habits.
Advisor (Subject advisor/external expert)	
Report writing	

The lesson delivery of Teacher C that was observed by three teachers in this lesson study group lasted for 60 minutes. The topic taught by the teacher was 'Feeding habits of animals with focus on carnivores, herbivores, and omnivores. The teacher used the pictures of animals as teaching resources. Behavioural words such as 'identify' and 'classify' featured in the lesson plan of Teacher C.

Table 10*Lesson Study Observations for Teacher C (Life Skills, Grade 3)*

Duration	Description of teacher's activity	Description of learners' activities
Teacher A	The teacher asked learners to write down 10 animals they knew.	The learners wrote animals that they knew.
10min	The teacher asked learners to group the animals according to their feeding habits	Learners carried out the instruction and each row had to put their answers on the board.
10min	The teacher showed learners and classified them according to their feeding habits	Learners were to compare their answers- what they had written with what the teacher had written.
10min	The teacher gave explanation of herbivores, carnivores, omnivores.	Learners were not satisfied about their dogs. They thought dogs were omnivores not carnivores because some treated dogs as pets and eat with their dogs.
15min	Herbivores are animal that feed on plants only. Carnivores are animals that feed on both meat and plants. Learners were given pictures of other animals (wild animals) to classify.	Learners were to classify the animals including wild animals in their assessment.
Teacher B 15min	The educator asked learners to write down ten animals they knew	The learners wrote animals that they knew.
10min	The teacher asked learners to group the animals according to what they eat.	Learners carried out the instruction. Anyone who finished his/her task, put the answer on the board.



Duration	Description of teacher's activity	Description of learners' activities
10min	The teachers showed the learners and classified the animals according to their feeding habits.	Learners compared their answers to those of the teacher.
10min	The teacher emphasised that animals were classified as carnivores, herbivores and omnivores	Learners were surprised about the classification of dog as a carnivore not omnivore.
15min	Short assessment task was given to learners, including classifying wild animals and birds.	Learners were to do the assessment tasks.
Teacher C 10min	Round-robin of writing down 10 animals they knew	The learners wrote animals that they already knew from home.
	Learners were to group animals according to feeding habits.	Learners did- each one wrote his answers on the board.
	The teacher explained the feeding habits of animals.	Learners compared their answers to what they had written and what they were told.
	Gave correct explanation and showed the structure of animals' teeth	Learners could not understand about dog.
	Teacher included pictures of wild animals and birds to let learners classify them.	Correct classification of animals was given to the teacher.

The analysis of the documents submitted in the 'Portfolio of Evidence' by Teacher C shows that learners had difficulty understanding the appropriate classification of carnivores and omnivores. One of the teachers that observed Teacher C's instructional session noted this:

"The teacher gave explanation of herbivores, carnivores, omnivores. Learners were not satisfied about their dogs. They thought dogs were omnivores, not carnivores because some treated dogs as pets and eat with their dogs. Observed Teacher A".

Unfortunately, the excerpts of the lesson study observational form show that Teacher A wrongly defined the scientific concepts of 'Herbivores' and 'Carnivores'. Teacher A's definition of these concepts went thus:

"Herbivores are animal that feed on plants only. Carnivores are animals that feed on both meat and plants. Learners were given pictures of other animals (wild animals) to classify.

Observing Teacher A". Another teacher that observed the lesson corroborated Teacher A as follows:

"The teacher emphasized that animals are classified as carnivores, herbivores and omnivores. Learners were surprised about the classification of a dog as a carnivore not omnivore" Observed, Teacher B".

Despite Teacher A's further explanations on the appropriate classification of dogs to the learners, Observer Teacher C affirmed that:

"Gave correct explanation and showed the structure of animals' teeth. Learners could not understand about the dog".



Table 11*Post Instructional Reflections of Teacher C*

Duration	General Observations	Lesson Evaluation	Changes	Challenges
Implementing Teacher	The lesson went well because learners could state the feeding habits of animals, carnivores, herbivores, and omnivores.	Learners could not classify their pet animals such as dogs, cats. They classified them as omnivores because they feed them porridge as well as other foods at home.	Correct explanation of feeding habits scientifically and the correct way of feeding animals.	They could not really understand why a dog is not an omnivore but a carnivore.
Observing Teachers	New knowledge was gained by learners and they enjoyed the lesson.	The feeding of their dogs. They used to feed dogs with leftovers of food.	Emphasized the correct feeding habits of animals. The practical situations at their homes could be corrected.	Learners could not really understand why a dog is a carnivore.

During the post-instructional reflections on the lesson delivery, the implementing teacher (Teacher C) stated the aspect of the lesson that did not work well as follows:

"Learners could not classify their pet animals such as dogs, cats. They classified them as omnivores because they feed them porridge as well as other food at home. They(learners) could not understand why a dog is not an omnivore but a carnivore"

The observing teachers concluded on Teacher C's instructional practice in this manner:

"The feeding of their dogs. They (learners) used to feed dogs with leftovers of food. Learners could not really understand why a dog is a carnivore."

The excerpts from Teacher C's instructional practices shows that he/she taught a controversial topic in Science Education. The records on the lesson study observational form attested to the use of 'Round Robin' strategy by Teacher C during the implementation of this instructional strategy. However, it would have been good if Teacher C repeated the lesson by adopting inquiry-based scientific teaching strategy. The observer teachers recommended an alternative approach that:

"Emphasises (i.e. Teacher C) the correct feeding habits of animals. The practical situations at their homes could be corrected"

Table 12*Pre-instructional Plan of Teacher D*

Date	20/02/2013
Place/School	Petsana Intermediate School
Time	08h00 – 09h00 (60minutes)
Name of All Participating Teachers	Martin K.N., Nkanga, L.J., Dihla, M.M., Moshoe, N.M. Nyamu, E.M.
Implementing Teacher	Nkanga L.J.
Facilitator/Group Leader	Mrs. Moshoe, N.M.
Class	1B
Subject	Life –Skills
Topic Selected for the Lesson	Colours
Prior Knowledge of the students	Learners were asked to give colours that they already knew.
Intended Outcomes	Learners to be able to recognize that we have different colours.



Date	20/02/2013
Content to be covered	Learners to be able to know colours and to identify different colours
Resources	Poster of colours, crayons, and books.
Lesson activities	Learners were given pictures to colour with correct colours.
Assessment Activities	Learners were given different pictures and they identified colours.
Advisor (Subject advisor/external expert)	
Report writing	

Teacher D did not seem to apply the knowledge he/she acquired from the SANRAL Chair in Science and Mathematics' Short Learning Intervention Programme because the lesson plan fell short of the standard that could be attributed to the application of knowledge acquired at the intervention workshops. The pre-instructional preparations were fraught with immeasurable lesson outcomes, activities, and assessments.

Table 13

Lesson Study Observational Form for Teacher D (Life Skills, Grade 3)

	Description of teacher's activity	Description of learners' activities
Teacher A	The teacher asked learners to give colours they already knew.	Learners named colours that they knew.
	The teacher showed learners the poster with different colours.	Learners identified colours.
	The teacher put objects with different colours on the board and asked them to match them with other objects with the same colours.	Learners coloured the pictures correctly.
	The teacher asked learners to identify colours.	Learners identified colours.

Despite the inadequacies in the pre-instructional preparations, the lesson lasted for 60minutes, and topic covered during the lesson was 'Colours'. However, the implementation of the lesson by Teacher D was better than the preparations outlined in the lesson plan. A teacher that monitored the instructional activities opined that:

"The teacher put objects with different colours on the board and asked them to match them with other objects with the same colours. Learners coloured the pictures correctly. The teacher asked learners to identify colours. Learners identified colours. Observed Teacher A"

Table 14

Post Instructional Reflections of Teacher D

	General Observations	Lesson Evaluation	Changes	Challenges
Implementing Teacher	Learners were able to give different colours that they already knew. They were participating very well.	Other colours on the poster were not familiar to the learners	Posters must have colours that are familiar to learners	Too-many learners in the class that the educator could not pay attention to all of them.
Observing Teachers	Learners were actively involved and could identify colours correctly	Learners could not name and identify colours that were not familiar.	Teach learners by telling them the names of colours that are not familiar. Then self- discovery method is too high for them.	Overcrowding is a hampering factor.

During the post-instructional reflection stage, Teacher D highlighted the challenges inherent in the lesson he/she presented as follow:



"Too-many learners in the class that the educator could not pay attention to all of them."

The observer teacher stated that:

"Teach learners by telling them the names of colours that are not familiar. Then self- discovery method is too high for them. Overcrowding is a hampering factor."

It is evident that the self-discovery was not ideal for the learners taught by Teacher D as well. The teacher realized that the learners found it difficult to identify some colours on the poster she used as instructional material despite teaching the concept of 'Colours' for an hour. From these excerpts, inappropriate teaching strategy and overcrowded classrooms emerged from Teacher D's instructional practices.

Discussion

This research examines the pre-instructional, instructional practices, and post instructional reflections of Science teachers in rural learning ecologies. The outcomes of this intervention (See Tables 1-14) suggest that the selected Science teachers believe that lesson study groups are effective in teaching the concepts of insulators and conductors, living organisms, water resources, feeding habits of animals, and colours in Science. In Reitz, the lesson study group was made up of teachers in schools located in this geographical area. Jita and Mokhele (2014) referred to this lesson study group as a 'cluster' which comprises a group of teachers from common or heterogeneous schools in a geographical location. The lesson study group enabled these Science teachers to collaboratively plan the Science lessons, assess the implementation of the lessons, and provide constructive feedbacks on the lessons taught to members of the lesson study group. This served to develop their professional capacity. The lesson study group constituted by these teachers in Reitz provided them the opportunity to experiment with knowledge and teachings skills acquired from the SANRAL Chair in Science and Mathematics Short Learning Intervention Programme. Second, the Science teachers' professional development was also enriched through the implementation of these lessons.

Pre-Instructional Practices

The instructional activities that took place before the Science lessons were taught show that the implementing teachers prepared standard lesson notes on each science concept that was taught. The lesson notes have important features such as: intended outcomes (objectives), content taught, resources (instructional or teaching materials), lesson activities, and assessment activities (evaluation). The preparatory activities of these Science teachers align with Nagro, Fraser, and Hooks (2019) of proactive teachers. Nagro et al. (2019) described 'proactive teachers' as instructors that take a proactive approach to the management of classroom by planning instruction with focus on engagement to give learners additional support that is in line with the contents of the general curriculum.

The use of behavioural words such as: 'identify' which falls in cognitive domain of 'remembering' featured in the lesson preparation of this teacher. For instance, a teacher in the lesson study group stated in the intended outcomes of her lesson that:

'Learners must be able to identify insulators and conductors-Not all objects conduct electricity.'

The behavioural term 'identify' also featured in the lesson of two other teachers in this lesson study group. The use of this word, to us implies that the lessons were geared towards enabling learners recognise scientific concepts, and hallmark of Science Education. The statement of intended outcomes with the use of a behavioural word such as 'identify' confirms Weisi and Zamani (2015) assertion on Anderson and Krathwohl's (2001) taxonomy that remembering ' entails retrieving relevant knowledge from long term memory that has a direct relationship with the cognitive processes of recognising and recalling.

Instructional Practices

In discussing the instructional practices of the Science teachers, this quotation from a teacher that observed the lesson presented by Teacher A is worth revisiting:



'The teacher asked the learners to predict which objects and (were) insulators and which were conductors. Learners wrote insulators and conductors of electricity in their flip charts and answers were corrected by the educators together with learners.'

The comment of this observing teacher unveils the kind of instructional practice provided by Teacher A. It is evident from this quote that Teacher A led the learners to predict and not identify as stated in her lesson plan. A scientific dimension in the lesson delivery of Teacher A that is worth noting is the use of flip charts for assessment activities. The adoption of flip charts by teacher A for the evaluation activities in this lesson affirms Holmes, Tracy, Painter, Oestreich, and Park's (2015) position that it is a basis to transit to user friendly technology in the classroom to improve students' engagement. The use of flip charts by Teacher A and the learners is worth mentioning since from the position of Holmes et al. (2015) it would have equipped the learners and Teacher A to use Google Apps which is a modern Apps for education.

A teacher who was a member of the lesson study group that observed the instructional delivery of Teacher B stated that:

"The teacher asked learners questions about water (importance of water). The teacher explained the use of water (bathing, cooking, drinking, watering plants (demonstration). A worksheet was distributed to learners by educator on uses of water. Worksheets were used as notes to learners" Observing Teacher 2c.

The use of worksheets as notes by the teacher that presented this lesson attests to supplementary instructional delivery that goes beyond the use of social science textbooks. It is expected that the Grade four learners would effectively master the scientific concepts of 'water' with the use of demonstration method supplemented with worksheets. The instructional practice exhibited by Teacher B confirms the claim assertion of Deniz, Gerofsky, and Nicol (2014) that worksheets are instrumental to effective instructional delivery in Mathematics, which is a discipline in Science Education.

The instructional delivery of Teacher C seemed to be methodologically appropriate, from the documents analysed on the 'Portfolio of Evidence. The appropriateness of Teacher C's instruction might be attributed to the fact that she observed the instructional deliveries of Teacher A and B. Unfortunately, the instructional knowledge of Teacher C seemed inadequate. It is worthwhile to revisit the comment of a member of the lesson study on Teacher C's instructional delivery as follows:

"The teacher gave explanation of herbivores, carnivores, omnivores. Learners were not satisfied about their dogs. They (the learners) thought dogs were omnivores not carnivores because some treated dogs as pets and ate with their dogs." Observing Teacher A.

The inadequate knowledge of Teacher C on the instructional content in life skills was further compounded by the definition provided in the lesson study observational form. In the pre-instructional preparation, Teacher C defined the scientific concepts of 'Herbivores' and 'Carnivores' as:

"Herbivores are animals that feed on plants only. Carnivores are animals that feed on both meat and plants. Learners were given pictures of other animals (wild animals) to classify."

Unfortunately, the inappropriate definition provided by Teacher C compounded her efforts at clarifying these concepts. One of the teachers that observed this lesson presentation stated that:

"The teacher emphasized that animals are classified as carnivores, herbivores, and omnivores. Learners were surprised about the classification of a dog as a carnivore not an omnivore (Observing Teacher A)."

The confusion that occurred in Teacher C's lesson presentation confirmed Kleickmann et al.'s (2013) assertion that pedagogical content knowledge (CK) is a primary element of teacher's competence that hinders student progress. It was evident from the quotes credited to Teacher C that she did not understand why the learners were confused about whether dogs are carnivores or omnivores, and the clarification she provided attested to teacher C's difficulty to understand why it was so (Shulman, 1986; Shulman, 1987). The inability of Teacher C to professionally clarify the concepts of carnivores, omnivores, and classify dog in one of these categories confirmed the position of Kleickmann et al. (2013) that the evaluation of teacher's knowledge remains a critical challenge in teacher education research. The analysis of Teacher D's lesson plan shows that the application of the knowledge acquired



from SANRAL Chair in Science and Mathematics Short Learning Intervention Programme was non-existent in her pre-instructional preparations. However, it is evident that Teacher D excellently presented the lesson on 'Colours' to the learners despite the flaws observed in her pre-instructional preparations.

The professional implementation of the lesson presented on colours could be attributed to the knowledge this teacher had acquired from critique of the lessons taught by other members of her group. This situation brings to fore the benefits of the lesson study group (i.e. cluster system) which Ajani and Samantha (2018) described as effective approach for teachers regardless of the phase or discipline in which they function.

Post-Instructional Reflections

During the post-instructional reflections on the lesson presented, the teaching strategy adopted by Teacher A seemed the most focal point of discussion for Observing Teacher/A. It will be good to re-examine the post-instructional reflection of Observing Teacher A:

"Learners were actively involved throughout the lesson answering of questions, prediction, observation, as one learner performed the experiment. Limited resources. It will be better if each group had its resources and conduct the experiment. Make resources available for each group. Self-discovery for Grade 6 is too high for them. Explain clearly to learners about the concept of insulators and conductors"

The issues that featured as difficulties in the presentation by this teacher are limited instructional or teaching resources, and the use of an inappropriate strategy to foster the learning of insulators and conductors. The realities of the classroom during the lesson presentation suggested to the observing teacher in the lesson study group that the self-discovery strategy seemed inappropriate for the cognitive level of the learners. The scenario that played out in the lesson presentation of Teacher A confirms the position of Guirguis, and Pankowski (2017) that teachers must ascertain how their students learn and the related strategies that are suitable for a cohort of learners in the process of learning. It is obvious from the observation of Teacher A that she did not fully study the students she taught to ascertain the scientific teaching strategies that are suitable to foster learning.

Another important factor that featured in the post-instructional stage of Teacher A's instructional delivery was overcrowding. Teacher A emphatically realised that the overcrowded atmosphere of her classroom hindered the effective lesson presentation on 'insulators' and 'conductors'. Marais (2016) reflected on the difficulties posed by overcrowded classrooms and stated that schools in South Africa had far more learners in one classroom. The experience of Teacher A confirmed the opinion of Shirley (2017) that overcrowding could potentially create beliefs to stakeholders such as parents, teachers, and communities that learners' academic performance is negatively affected.

However, on a painstaking examination of Teacher A's self-reflection that:

"They (Learners) could not confidently give reasons as they were doing the presentations. Learners were not exposed to the method of presentation in their previous class. Learners could not express themselves confidently and they could not respond to some questions from other learners. Overcrowding is a contributing factor to my teaching."

It seems to the researchers that Teacher A might have complained about an increased class size and not overcrowding, which Shirley (2017) posited as one of physical effects of overcrowding. The teacher that observed the instructional delivery of Teacher C remarked that the 'Round Robin strategy adopted by this teacher did not yield the desired results.

This excerpt explains the aspect of the lesson that did not work well that made the observing teachers suggest the instructional teacher to repeat the lesson on feeding habits of animals (Carnivores, Herbivores, and Omnivores) using inquiry-based scientific teaching strategy:

"The feeding of their dogs. They (Learners) used to feed dogs with leftovers of food. Learners could not really understand why a dog is a carnivore"

The confusion that played out during the instructional implementation of Teacher C's lesson is called 'misconceptions', which Mataka and Taibu (2020) posited as great challenges to students' learning irrespective of their



educational level. It is evident from the lesson study group's conclusion of the observing teachers of this lesson that the inquiry teaching strategy is more suitable than 'Round Robin' teaching strategy. The suggestion of inquiry teaching strategy supports the assertion of Mataka and Taibu (2020) that teachers should adopt active learning or inquiry-based learning to teach misconceived topics or controversial topics in Science Education.

Finally, the post instructional reflection of Teacher D confirmed that 'overcrowding' and not increased class size, as earlier suggested by the researchers, posed the greatest risk to effective instructional delivery in Reitz's schools. The confirmation of Teacher D on the challenges that affected the effective instructional delivery is evident in these excerpts:

"Too-many learners in the class that the educator could not pay attention to all of them".

The view of the Teacher (i.e. Teacher D) that presented the lesson was complemented by a teacher that observed the lesson who stated that:

"Teach learners by telling them the name of colours that are not familiar. Then self-discovery method is too high for them. Overcrowding is a hampering factors".

Conclusions and Implications

Findings from this research have attested to the benefits inherent in the lesson study classroom practices of Science teachers at Reitz. This research has unearthed fundamental factors such as inappropriate use of behavioural words in Science lesson plan preparations, use of nebulous instructional strategy, inadequate pedagogical content knowledge, and overcrowding, as what affect instructional delivery in Science Education. Despite these shortcomings, the appropriate planning of lessons, and use of instructional resources seemed to the researchers as perceived benefits that the teachers that constituted this lesson study group gained from the SANRAL Chair in Science and Mathematics Short Learning Intervention Programme. Another benefit of this research could be seen in the collaborative planning, implementation, and evaluation of the Science lessons which contributed immensely to the professional development of these selected Science teachers at Reitz.

It is evident from this study that future capacity building programmes by the SANRAL Chair in Science and Mathematics Education should focus on equipping Science and Mathematics teachers with the knowledge to select appropriate teaching strategies for teaching Science and Mathematics concepts. Furthermore, the findings of this research suggest that researchers might develop a blueprint for teachers in the science disciplines, in order to overcome the challenges posed by overcrowding in South African schools. It should be noted that this paper justifies the use of constituted lesson study groups or teacher clusters as the most beneficial arrangement for the teachers' professional development in South Africa which could be adopted by researchers in other nations such as Botswana and Honduras, for professional development programmes for Science and Mathematics teachers that featured on TIMSS's reports.

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