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The Impact of Nurturing Talent in A Science, Engineering and Technology Programme on Learner Performance in Physical Science

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Abstract

This paper investigated the impact of the Nurturing talent in Science, Engineering and Technology (NSET) programme on teaching practices in rural schools within the Nkowankowa cluster in the Limpopo Province. Though NSET programme focused on Science, Mathematics and Technology, this study will only concentrate on Physical Sciences. Out of the population of 68 Science teachers, 30 participated in the completion of questionnaires and nine were interviewed. A mixed-methods approach with an exploratory design was used in this study to investigate the impact of the NSET programme on learner performance in Physical Sciences (focusing on teacher content and pedagogical delivery). For learners to consistently perform better, then one need to focus on teacher development in terms of content and pedagogy. The model that focuses on teacher development in order to address the performance of learners helps to sustain better results at school than focusing directly on learners since the teachers are likely to interact with more learners and stay at the same school longer. Questionnaires, interviews and document analysis were used as data collection methods. According to the research findings, the NSET programme had a positive impact on both the content and pedagogical delivery of teachers. This was revealed through the confidence educators gained and their ability to come up with new teaching strategies and improved teaching practices. The positive impact of the NSET programme is also noted through learners' improved academic performance in Physical Science. The NSET programme conducted within the Nkowankowa cluster yielded positive results and the Limpopo Department of Basic Education (DBE) can adopt it as one of the best practices in the development of teachers and improvement of results in their schools.

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INTRODUCTION

The teaching and learning of Physical Science in South Africa in the post-apartheid era is intended to address the shortage of skills mainly in the critical areas of Science, Engineering and Technology (NSET) (Department of Education, 2017). According to (Department of Education, 2017), Physical Science is an important subject, because it focuses on the investigation of physical and chemical phenomena using scientific methods. Qualified personnel in this subject are therefore a priority for success in addressing the shortage of skills in Science, Engineering and Technology careers.

The researcher's personal experience suggests that there are several contributing factors to the poor performance in Physical Science among the poor rural school learners. These are learners from previously disadvantaged communities without enough resources to enhance learning and teaching. Moreover, most parents are not able to come to the aid of these children, since they themselves are a product of the system (segregated learning) that did not promote proper learning for these parents (Wolhuter, 2013). According to (Dhurumraj, 2013), Physical Science is a subject that has cognitive prerequisites such as scientific and analytical thinking. As a result, learners require mathematical and problem-solving skills. It is therefore, difficult for learners to achieve good results in Physical Science if they are struggling with Mathematics or doing Mathematical Literacy.

The Grade 12 results for 2011, 2012 and 2013 for Limpopo province were 31.0%, 36.1% and 39.8% respectively (Department of Education, 2017). (It should be noted that the three highlighted years above are related to the phenomenon of nurturing talent in Science, Engineering and Technology intervention which was investigated). Even for the previous 5 years, the results of learners that performed at 40% and above in Physical Sciences are still very low at 39.5% for 2016, 42.2% for 2017, 48.7% for 2018, 51.7% for 2019 and 42.4% for 2020. The results in most of the rural schools in Limpopo were worse than the provincial average and this was the major reason why the results were this low. Even if these learners obtained a pass in Physical Sciences it is highly unlikely for them to pursue degree studies in Science, Engineering and Technology fields at universities with marks below 40%. For this study, the focus was on teachers.

In a study done by (Sutton, 2011), entitled, improving the impact of teachers on pupil achievement", it was highlighted that teachers are the main asset in improving the performance of schools. So, by improving the effectiveness of teachers at the schools, learners would achieve more and that will have a positive impact on the education system across the country. This is in line with the premise that the quality of the education system is determined by the quality of its teachers. This study attests to the fact that teachers are the most important factor within schools and policymakers can turn to for the improvement of learner achievement. Reference (Department of Business Innovation & Skills, 2014) further highlights that teachers in secondary schools need content/subject knowledge in science in order to arouse and satisfy the element of wonder in learners. This will quicken and cultivate the faculty of observation. In turn, observation teaches a learner to reason from facts that come under his own notice.

According to (Dhurumraj, 2013; Izquierdo-Aymerich & Aduriz-Bravo, 2003), content knowledge and experience are not the only guarantee that learners are going to improve performance, but ability of the educator to capture the attention of the young minds, and to probe them to think and also the ability of the educator to take into consideration learner conceptualisation in order to assist the learners to integrate existing concepts about science with new concepts being taught guarantees improvement in learner performance (Hewson & Hewson, 1987). In a sense, it says that a teacher should be able to employ multiple teaching methods in accordance with the learners' needs (Fosnot, 1993; South African Radio Astronomy, 2019].

Reference (Kriek & Grayson, 2009) views teachers' limited content knowledge as one of the major contributing factors to learners' poor performance in Physical Science. However, the two authors also emphasize two more contributing factors. The factors are ineffective teaching approaches and unprofessional attitudes of Physical Science teachers. They argue that these are some of the factors contributing to the poor state of science in South Africa (Kriek & Grayson, 2009).

A similar line of thinking is shared by (King'aru, 2014) who views poor performance in Science among secondary school leaners as due to poor pedagogical and lack of adequate content knowledge. Reference (Makgato & Mji, 2006) also maintain that limited content knowledge is one of the causes why learners perform poorly in Physical Science.

This study is underpinned by the theory of Constructivism and Pedagogical Content Know-

ledge (PCK). These two theories are shared next.

Elliot, Kratochwill, Littlefield & Traver (2000) defines Constructivism as "and approach to learning that holds that people actively construct or make their own knowledge and that reality is determined by the experiences of the learner." In addition to this, (Arends, 1998) states that Constructivism believes in personal construction of meaning by the learner through experience, and that meaning is impacted by the interaction of prior knowledge and new encounters. So, Constructivism's main idea is that human learning is constructed and that learners build new knowledge upon the foundation of previous learning. It follows also that learning is an active process and involves both the learner and teacher. Constructivism in this study applies in that teachers attempt to construct knowledge during lessons planning, teaching and reflecting on lessons within an environment where teachers and learners collaborate socially with one another. In such a setting, educators are able to learn from each other, thus be able to teach with confidence and enthusiasm. Teachers are able to improve their Pedagogical Content Knowledge and effectiveness by engaging with each other in their own social environment. Teachers also learn from their experiences and challenges in developing lessons for their learners, since a teacher is tempted to teach the same way that he has been taught.

Vygotsky (1978) is of the opinion that the most significant moment in the process of learning and intellectual development takes place when practical work and speech converge. So through practical activities a learner can construct meaning on an intra-personal level. Gash (2014) believes that learners compare their version of truth with that of the teacher and fellow learners to get a new, socially tested version of truth. This suggests, therefore that some learning strategies include peer collaboration, problem-based teaching and other approaches that involve learning with others.

According to (Rollnick & Mavhunga, 2017), Pedagogical Content Knowledge refers to specialised knowledge and content that needs to be taught which is possessed by teachers. Rollnick states that this kind of knowledge is often hidden, since teachers do not realise that they possess such important and valuable knowledge. This combines both the methods of teaching and the content that needs to be taught. It involves examples, analogies, explanations, practical and experimental learning. To improve learner performance in Physical Sciences, teachers' Pedagogical Content Knowledge needs to improve. The understanding is that when one gets it right with the teachers then learners will be able to learn better and perform better. For this study therefore, Constructivism theory and Pedagogical Content Knowledge are seen to be complimentary.

This study followed a mixed-methods approach and it focused on the impact that the Nurturing talent in Science, Engineering and Technology (NSET) programme had on learner performance in Physical Sciences; it also focused on teacher pedagogical and content delivery. The word impact in this case refers to the significant effect that the NSET programme had on learners' performance in Physical Sciences, focusing on teachers' pedagogical and content delivery. Pedagogical knowledge refers to the methods of teaching that a teacher has acquired and uses during learning and teaching, while content knowledge refers to how much knowledge a teacher has on a specific subject and in this case, Physical Sciences. Reference (Makgato & Mji, 2006) proposes that subject content knowledge and methodology of the teachers in Physical Science contribute to the performance of learners in Physical Science. These authors argue that firstly one teaches the way one was taught. It is very natural for one to use the methodology in which one was taught as that is the simplest way that one knows.

Teachers with limited Pedagogical Content Knowledge will in turn provide limited content to the learners they teach. It is for these reasons highlighted above that this study (to investigate the impact that the NSET programme had on learner performance focussing on teacher's Pedagogical Content Knowledge was conducted.

Main research question: What impact did the NSET programme have on Physical Sciences teachers' performance in pedagogical and content delivery?. Sub-research questions: How did the NSET programme contribute to the teaching practice of educators in Physical Sciences?Did the teacher participation in the NSET programme improve the performance of their learners in Physical Sciences?

METHODS

A mixed-methods (qualitative and quantitative) approach was used in this study. A mixed-methods design combines both qualitative and quantitative questions, methods, and analysis in a single study. It also incorporates the strengths of both qualitative and quantitative designs to capture the unique findings (McMillan & Schumacher, 2010). McMillan and Schumacher (2010) also

allude to the fact that a mixed-method approach gives an opportunity of showing results quantitatively and simultaneously explains why they are obtained qualitatively. Furthermore, the type of the mixed-methods approach is a triangulation design and it is exploratory. The main reason for this was that both types of data are collected and analysed at the same time and it is efficient. A mixed-methods approach encompassing both qualitative and quantitative investigation into the Impact of the NSET programme on learner performance in Physical Sciences, focusing on teacher content and pedagogical delivery.

Within this mixed-methods approach, a qualitative approach was also used, because the study was conducted in a real environment where teachers live. The participants were able to describe their everyday experiences that related to challenges that they face in the learning and teaching of Physical Sciences. Cresswell (2007) states that "qualitative research is a collection of assumptions, a world view, the possible use of a theoretical lens, and the study of research problems inquiring into the meaning individuals, or groups ascribe to a social or human problem."

The NSET programme was rolled-out in four different clusters which were Malelane, Bushbuckridge (Mpumalanga Province), Nkowankowa and Malamulele (Limpopo Province). For this study, the Nkowankowa cluster participated. The reason for choosing Nkowankowa is that it was easily accessible.

A population is a group of elements or cases, whether individuals, objects, or events, that conform to specific criteria and to which we intend to generalise the results of the research (McMillan & Schumacher, 2001). Schooenenboom and Johnson (2017) also describe population to mean a group of persons or set of objects the researcher intends to gain information and draw conclusions from. The population of this study consisted of 68 teachers from eight secondary schools from Nkowankowa, in Limpopo Province, South Africa.

A sample refers to the group of subjects from which data are collected and represents the population (McMillan & Schumacher, 2014). It can also be viewed as a survey population or subject of measurements which is drawn from a population in question. Mouton (2000) also define sampling as the process of selecting subjects or characters to generalise results.

Data Collection

Data were gathered from multiple sources, which include questionnaires, semi-structured interviews and documents analysis. Questionnaires were sent to Physical Sciences teachers who participated in the programme. The interview schedule was developed in line with the questionnaire to ascertain the findings. The interviews focused on receiving increased response rates and help the researcher to have an in-depth understanding of Departmental Heads, Deputy Principals and Principals of the schools' responses that are already in the questionnaires and the documents to be reviewed. Documents such as lesson plans, lesson preparations, mark schedules, enrolment registers and what the previous researchers said about the topic.

A sample of nine teachers from three schools from Nkowankowa participated in the qualitative interviews. The composition of the interview teacher sample was as follows: One principal per school (three principals); One HOD of Physical Science per school (three HOD's); and One teacher of Physical Science per school (three Physical Science teachers).

For the quantitative data collection, a total of 35 teachers received the questionnaires to complete and 30 were returned. Convenient and purposeful sampling were used for this study. Patton (2002) highlights the importance of convenient and purposeful sampling in that it selects, "information rich cases for in-depth study." Patton (2002) alludes to the fact that information-rich cases are cases from which one can learn a great deal concerning issues of central importance to the purpose of the study.

Analysis of quantitative data

Pearson Correlation Coefficient was used for the analysis of the quantitative data. So SPSS statistical package was utilised. The correlation coefficient (r) ranges from -1 (a perfect negative correlation) to 1 (a perfect positive correlation).

Analysis of qualitative data

Analysis of data obtained from individual interviews was done through identifying themes, patterns, trends, and relationships from the respondents' description of their experiences (Mouton, 2000). Relevant information was broken into phrases or sentences which reflect a single specific thought. Irrelevant information was separated from the relevant information from the interviews. Amongst the respondents, were Deputy Principals and Principals where these teachers taught? Including Principals and their deputies was done to ascertain what the subject teachers were saying in the questionnaires hence the responses like, "teachers were teaching at a

different level etc."

RESULTS AND DISCUSSIONS

The findings and discussions from questionnaires are shown Table 1. Table 1 shows a very strong positive correlation between the NSET programme enabling teachers to use strategies that actively engage students in Science and its focus on knowledge of how students learn the particular Science content (r=.928; p<.01). This relationship was also found to be significant at the 0.01 level. There was also a strong positive correlation between the NSET programme enabling teachers to use strategies that actively engage students in Science and how NSET encourages coherence in teachers' overall professional development experience (r=635; p<.05). This relationship was also found to be significant at the 0.05 level. The study also found that there is a strong positive significant correlation between the NSET programme enabling educators to use strategies that actively engage students in science and how the NSET promotes collaboration among teachers (r=655; p<.01). This relationship was also found to be significant at the 0.01 level. It was further found that NSET programme enabling educators to use strategies that actively engage students in Science had a strong positive correlation with how it engages teachers in reflecting on and assessing their own efforts to promote inquiry, reasoning, problem solving, and communication in the classroom (r=636; p<.01). This relation was found to be at 0.05 level of significance.

More than 50% of all the responses believed that the NSET programme provided them with a tremendous amount of help as they began to practice what their learnt during the NSET programme intervention.

Table 2 shows a moderate positive correlation between teachers' improved pedagogical knowledge and content, since the introduction of NSET programme and the same teachers setting appropriately challenging expectation for learners (r=434; p<.05). This relation was found to be significant at 0.05 level. There was however a weak but significant positive correlation/relationship between teachers' improved pedagogical knowledge and content, since the introduction of NSET programme and the ability of learners to solve science problems on their own (r=330; p<05). The relationship was found to be significant at the 0.05 level of significance. This study also found that there is a moderate positive correlation between teachers' improved pedagogical knowledge and content since the introduction of

Table 1. The relevance of the NSET

	NSET focuses on knowledge of how students learn a particular content	NSET encourages coherence in teachers' overall professional development experience	NSET promotes collaboration among teachers	NSET programme engages teachers in reflecting on and assessing their own efforts to promote inquiry, reasoning, problem solving, and communication in the classroom.
NSET programme enables teachers to use strategies that will actively engage students in Science	r=.928** n=30	r=.635* n=30	r=.655** n=30	r=.636** n=30

Table 2. The correlation between teachers' improved pedagogical knowledge and content

Activities	Setting appropriate/ challenging Expectation of learners	Learners solve science problems on their own	Teachers ask learners to explain reasoning behind an idea	Teachers use group work as a teaching approach
My pedagogical knowledge and content has improved since the introduction of the NSET programme	r=.434* n=30	r=.330* n=30	r=.559** n=30	r=.404* n=30

NSET programme and learners' ability to explain reasoning behind an idea (r=559; p<05). Furthermore, teachers' improved pedagogical knowledge and content since the introduction of NSET programme was also found to be moderately positive and significantly associated with using group work as a teaching approach where r=404; and p<.05.

It is evident from the table 3 that there is a strong positive correlation between teachers who attended the NSET workshops on Physical Sciences and their ability to plan Physical Sciences lessons with other teachers in their schools (r=742; p<.01). This correlation was found to be significant at 0.01 level. There is also a very strong correlation between teachers who attended the NSET workshops on Physical Sciences and their ability to observe other teachers in their schools teaching Physical Sciences in their classrooms (r=887; p<.01). This relationship/correlation was also found to be significant at the 0.01 level. This study also found that there was a strong positive significant correlation between teachers who attended the NSET workshops on Physical Sciences and ability to meet with a group of teachers to study/discuss issues related to the teaching of science on regular basis at school or district (r=606; p<.01). Furthermore, attending the NSET workshops on Physical Sciences by teachers is significantly associated with the teachers' meetings with a teaching mentor to discuss issues around Physical Sciences teaching where r=610 and p<.01.

Similar findings were found during the interviews concerning the participation in the NSET programme as alluded to by the respondents as one can see below:

Theme 1: Enhanced teaching practice

The teachers reported that they benefited much from the networking and innovative information shared during workshops. It also surfaced that the workshops were adapted, and new information was added to strengthen the programmes. The participants' responses are shared next.

Teacher 1 answered:

Yes, teachers began to come with new initiatives that they got from the programme that was not there before.

Teacher 5 said:

Yes, when I came back with the knowledge gained from the programme, I saw learners' results going up.

Teacher 8 said:

It has improved the work ethics of educators. The results have also improved.

Theme 2: Teacher confidence

The attention paid to teacher training during workshops transpired in a higher level of teacher confidence and motivation. The more informed the teachers became the higher their level of motivation was. Positive attitudes surfaced as crucial requirement for improved academic performance. It also emerged from the responses that teachers were guided in the practical implementation of Science experiments in class and to become innovative when lacking resources to do these experiments in class. Those who did not have resources learnt to use videos illustrating step by step how to conduct experiments. Since they also connected with other teachers, they could share resources and preparation.

Teacher 6 responded:

Teachers' and learners' confidence has improved. Other schools come to our school for assistance. Our teachers are asked by schools outside the cluster/ circuit to help.

Teacher 3 said:

Teachers that participated in the NSET programme have improved in that teachers were afraid to teach Grade 10 to 12, and they chose to teach lower grades, but after the introduction of the programme they were confident to teach Gra-

Table 3. The correlation between teachers who attended the NSET workshops on Physical Sciences and their ability to plan Physical Science lessons

	Plan Physical Sciences lessons with other teachers in my school	Observe other teachers in my school teaching Physical Sciences in their classrooms	Meet with a group of teachers to study/discuss issues related to the teaching of science on regular basis at school or district	Meet with a teaching mentor to discuss issues around Physical Sciences teaching
Attend NSET workshops on Physical Sciences	r=.742** n=30	r=.887** n=30	r=.606** n=30	r=.610** n=30

Table 4. Documents analysed

Document	Findings
Lesson plans	**Findings before training** The findings revealed that not all teachers initially knew the steps to follow in lesson planning. Not all teachers linked with the learners' background and previous lesson. Not all teachers had the time to plan properly. Only three of the seven teachers indicated the aims of the lesson and what learners were supposed to know at the end of the lessons. Teaching strategies were more teacher-centred and was teacher driven. **Findings after training** The findings revealed that teachers knew the steps to follow in lesson planning and could use work schedules as planned by the trainers and other knowledgeable teachers, Teachers linked with the learners' background and previous lesson. Teachers were more organized and motivated to keep a record of their preparation including lesson plans. All seven teachers indicated the aims of the lesson and what learners were supposed to know at the end of the lessons. Teaching strategies were more learner-centred and learners were more involved in their own learning.
The training programme	**Findings before training** Teachers were demotivated and uninvolved. Some were absent many times and evaded the issue of demonstrating experiments. **Findings after training** The training programme provided specific guidance on how and what to do. The programme provided opportunities for teacher involvement and feedback. The programme provided teacher support and examples of lessons with videos on experiments. The videos were clear and motivating. They attracted the attention of the learners and served as encouragement. Study groups were formed, and networking occurred. Collaboration assisted the teachers who struggled. Group work was very effective, and teachers learnt to communicate their problems to find solutions.
Mark sheets	**Findings before training** The teachers' marksheets were studied before and after the training. **Findings after training** The marks indicated that the programme had a significant influence on the teachers' level of motivation and confidence Learners were more motivated and after training the marks were higher.

de 10 to 12. Our content knowledge increased, and we discovered additional sources. We are now all comfortable to rotate from Grade 8 to 12.

Teacher 7 said:

It brought change and improved results significantly. It improved confidence in teachers. More learners are taking Maths and Science.

Teacher 5 said:

I am amazingly comfortable. I am at ease when I teach. It is no longer difficult for me, since because facilitators assistance provided us with videos which helped learners to focus their attention on practical experiments. The videos are also attention-grabbing and serve a strong motivational purpose.

Theme 3: Participation in NSET to improve academic performance

The workshops had a direct impact on the learners' academic performance. It emerged that there was a definite improvement on the learners' marks after attending the workshops and following the NSET programme. There were even learners who managed to obtain distinctions

whereas they were only performing moderately in the past. Their improved marks had a direct influence on their attitude towards the subject and the teachers. It was clear that there were many spin-offs from the programme and teachers were more involved in teaching their subjects.

Teacher 1 said:

Learners used to get below 60%, but after this programme, learners began to get 70% to 80% in the subject.

Teacher 2 said:

Yes, there has been improvement. Some learners obtained distinctions; some 40% have obtained distinctions. Others have obtained level 7 in their Grade 12 results.

Teacher 3 said:

Yes, for example, we had a learner who obtained 100% in Physical Sciences which is a sign that the programme helped. Even this year we will get 100% or close to it. So, the teacher participation has improved the performance of learners.

Teacher 9 said:

Yes, great improvement. Some learners are performing between 90 and 100%.

Teacher 7 added:

We are performing at 70 and 80% and a learner got 300 out of 300 in Physical Sciences and she received an award at a provincial level.

CONCLUSION

The study investigated the impact of the NSET programme on teacher practices in terms of pedagogical and content delivery, and how this impacted the performance of learners in Physical Sciences. The results showed that the NSET programme assisted teachers in enhancing their pedagogical and content delivery, which in turn improves the performance of learners in Physical Sciences (Spaull, 2013; Sutton, 2011). So lack of adequate pedagogical and content delivery knowledge is seen as contributing greatly to learner poor performance in Physical Sciences. The study also found that in-service training including sharing experience helps to make better educators (Spaull, 2013; Hughes, 2012; Rollnick and Mavhunga, 2017). Rollnick and Mavhunga (2017) also attests that combining methods of teaching and knowledge of content that needs to be taught is very helpful for teachers because they can come with examples, explanations, practical and experimental learning. Dhurumraj (2013); Izquierdo-Aymerich and Aduriz-Bravo (2003) add the issue of the teacher's ability to capture the attention of the young minds. The findings show that the NSET programme intervention has improved the teaching and learning in the Nkowankowa cluster. It also shows that teachers were able from this intervention to use new strategies in learning and teaching that assisted in improving the results of their schools. More than 50% of all the responses believed that the NSET programme provided them with a tremendous amount of help as they began to practice what they learnt during the NSET programme intervention.

The purpose of this paper was to investigate the impact of the NSET programme on teaching practices (in terms of pedagogical and content delivery, and how this impacted the performance of learners in Physical Sciences) in rural schools within the Nkowankowa cluster in the Limpopo Province, South Africa. It can be said that the NSET programme contributed positively to the improvement of teachers' pedagogical and content delivery of Physical Sciences. The findings are also such that the activities actively engaged learners Based on the findings, teachers can therefore use these strategies to enhance learning and teaching in their schools.

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