

# Understanding Science Teachers' Classroom Practice after Completing a Professional-development Programme: A Case Study

Maria Kekana<sup>1</sup>, Estelle Gaigher<sup>1\*</sup>

<sup>1</sup> University of Pretoria, SOUTH AFRICA

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## ABSTRACT

This article reports a study aiming to understand the classroom practice of four grade 7 science teachers following an in-service teacher-development programme. Such studies are needed to contribute to knowledge about the effectiveness of professional development programmes. Clarke and Hollingsworth's model of professional growth was used as a theoretical framework. Data were collected by means of interviews, lesson observations and document analysis. It was found that each teacher experienced professional growth in a personalised way, such as increased confidence, improved content knowledge, teaching strategies, practical skills, and valuing professional collaboration. All the teachers reported that their classroom practices have improved. Lesson observations revealed that three of the four teachers were enthusiastic and engaged their learners in practical work. Challenges such as lack of resources, poor language skills, and lack of higher cognitive levels in activities and questions were observed for all the teachers. An adapted model of professional growth has been proposed to represent the professional development of science teachers in poorly resourced schools.

**Keywords:** teacher professional development, science teaching, classroom practice

## INTRODUCTION

The ultimate goal of teacher-development programmes is the enhancement of learner outcomes through improved teaching practices (Desimone, 2009; Supovitz & Turner, 2000). This is in agreement with the views of Darling-Hammond, Hyler, and Gardener (2017, p. 12) when they defined effective professional development as "structured professional learning that results in changes to teacher knowledge and practices, and improvements in student learning outcomes". The emphasis on improving classroom practice is based on the strong relationship found between classroom practices of teachers and learner outcomes (Wenglinsky, 2002).

In South Africa (SA), professional development of science teachers is a priority, in view of poor learner performance in international assessments, poor Grade 12 results, the effects of curriculum changes since 1994, and the heritage of inadequate teacher training in the apartheid era. From 2003, a professional-development programme, the Advanced Certificate in Education (ACE), was introduced by Higher Education Institutions in SA. The purpose of the ACE programme was to upgrade and re-skill teachers (Department of Education [DoE], 2000). There was a rapid increase of ACE programmes on offer, though not in the subjects where it was needed most. The extent of this increase led to a review of the ACE programmes (DoE, 2007; Kruss, 2009). Consequently, it was replaced by a programme named the Advanced Certificate in Teaching (ACT) (Department of Higher Education and Training, 2011).

Despite the discontinuation of the ACE, there is a need to understand how it affected the practices of individual science teachers, as such studies are scarce (Avidov-Ungar, 2016). The current article contributes to the research literature by reporting a case study exploring four science teachers' views about how the ACE programme

#### Contribution of this paper to the literature

- The paper illuminates professional development from the perspective of science teachers in poorly resourced schools.
- Teachers experienced professional growth in personalised ways, such as increased confidence, improved content knowledge, teaching strategies, practical skills, and valuing professional collaboration.
- The paper presents a new model for professional development of science teachers, particularly in developing countries.

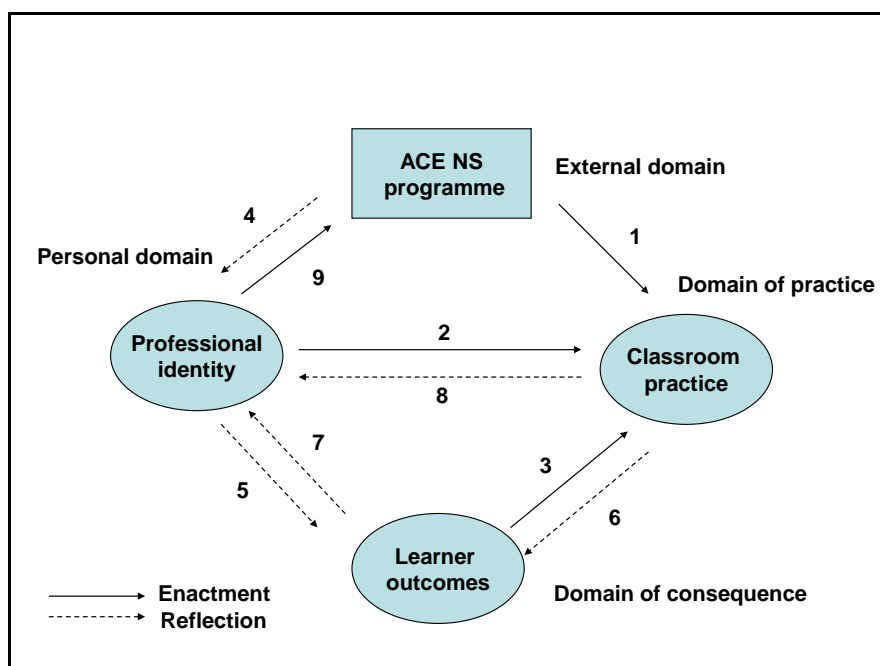
influenced their classroom practices. The aim of the study was to gain in-depth understanding of teachers' classroom practice after they completed the ACE programme. The following research question guided the study: How can the classroom practice of science teachers be understood after they completed an ACE Natural Science (NS) programme? Such understanding is vital to learn from the successes and challenges of the ACE programme when designing future professional development for science teachers.

### IN-SERVICE TEACHER PROFESSIONAL DEVELOPMENT

Teacher-development programmes are offered in different delivery modes such as certificate programmes, workshops, seminars, action research, coaching and mentoring (Loucks-Horsely, Stiles, Mundry, Love, & Hewson, 2010). Some of these modes of teacher development, like once-off workshops, are regarded as ineffective as they do not enhance learner performance (Borko, 2004; Darling-Hammond et al., 2017; Ono & Ferreira, 2010). However, it is acknowledged that workshops can serve a different purpose for example for the orientation of teachers on new policies. Desimone (2009), Guskey (2003), Garet, Porter, Desimone, Birman, and Yoon (2001), and Sandholtz and Scribner (2006) proposed some core features that should be taken into consideration when designing effective professional-development programmes: Firstly, programmes should be based on the analysis of learner performance and focus on what learners are struggling to learn in order to improve learner outcomes. Also, programmes should be school-based, ongoing, coherent and collaborative, and focused on teachers' needs for improving their practice. In the same vein, Darling-Hammond et al. (2017) proposed that effective programmes are content-focused, incorporate active learning, support collaboration, use models and modelling, provide coaching and expert support, offer feedback and reflection opportunities, and are of sustained duration. In the US, a large state-wide professional-development programme for mathematics teachers and administrators showed significant improvement of participants' knowledge and self-efficacy (Carney, Brendefur, Thiede, Hughes, & Sutton, 2016). These authors concluded that long-term, large-scale professional development may be more fruitful than intensive projects focused on smaller groups.

In South Africa, Aluko (2009) explored the impact of ACE in Educational Management on the professional practice of teachers. In this study the change in the teachers' professional practice was evaluated from the way teachers understood, interpreted and implemented educational policies after completing the programme. It was found that there was an improvement in the teachers' professional practice after completing the programme. Burton (2011) investigated teachers' perceptions about the use of a teaching strategy learnt in the ACE programme in the Eastern Cape. The strategy entailed using interactive notes on the website of the university. It was found that not all the teachers implemented the strategy as required, particularly the many teachers who resided far from the university who did not have access to the Internet.

Classroom practice is linked to professional identity (Beijaard, Meijer, & Verloop, 2004). Learners' responses on improved practice provide feedback that further improves teachers' identity. According to Desimone (2009), teachers' beliefs and attitudes need to be changed first before their classroom practice is changed, while Guskey (2002) proposed that improved learner outcomes precede changes in teachers' beliefs and attitudes. According to Avidov-Ungar (2016, p. 654): "Professional development is a process in which the professional identity of the teacher is formed, and implicit knowledge becomes explicit". Once implicit knowledge becomes explicit, it will permeate in the classroom. Subject knowledge is an important contributor to effective classroom practice (Garet et al., 2001; Harvey, 1999; Kruss, 2009; Mji & Makgato, 2006). It is widely accepted that learners understand science concepts better when they conduct practical work and observe real events (Millar & Abrahams, 2009). Mji and Makgato (2006) found that conducting experiments enhanced learner performance in science. Therefore, practical skill should be an important element in science teacher-development programmes. Burton (2011) found that the avoidance of practical work is caused by a lack of apparatus, while Muwanga-Zake (2000) found that it is related to a lack of teacher knowledge. The findings from these two studies indicate that, although lacking resources may sometimes be used as an excuse, the reasons for not conducting experiments may be multifaceted, including inadequate training of science teachers.



**Figure 1.** Theoretical framework based on Clarke and Hollingsworth's model of professional growth (2002, p. 951)

In South Africa, language skill is another important aspect of science classroom practice as classes are mostly taught in English, while English is not the first language of the majority of learners and teachers. Harvey (1999) recommended that language-skills development should be incorporated in the everyday classroom practice of science teachers. He further advised that teachers could develop scientific activities that would enhance learners' listening, speaking, writing and reading skills. However, Villanueva (2010) found in her study on integrated teaching strategies that science teachers were reluctant to address language skills in science.

Pedagogical skill is an important aspect of science classroom practice (Harvey, 1999). This includes the use of constructivist principles for teaching, use of discrepant events to explain science concepts, managing resources and learning activities in the classroom. General pedagogical skills support the understanding of deeper meanings of learner behaviour in the classroom by teachers (Stenberg, 2011) and their reaction in appropriate ways.

## THEORETICAL FRAMEWORK

Clarke and Hollingsworth's (2002) model of professional growth was used as a theory to frame the study. This model depicts the influence of a professional-development programme on classroom practice, professional identity and learner outcomes as a web of possible pathways of enactment and reflection. These alternative pathways make the model more versatile than the linear one-way model of Guskey (2003) and Desimone's (2009) linear two-way model.

**Figure 1** shows the framework, comprising of four interconnected domains, namely the external domain, domain of practice, personal domain and domain of consequence. In our study, these domains are represented by the ACE NS programme, classroom practice, professional identity and learner outcomes respectively.

The model makes it possible to describe how growth in any of the three internal domains influence each of the other domains through the processes of direct enactment or reflection. Specifically, teachers' classroom practice may be enhanced in three ways: direct implementation of something learnt in the ACE programme (arrow 1); planning and trying something new based on enhanced professional identity (arrow 2); and improved learner outcomes (arrow 3). Similarly, the teacher's professional identity may be enhanced by three influences: reflection on the ACE programme (arrow 4); learner outcomes (arrow 7); and classroom practice (arrow 8). Learner outcomes may be influenced by the teachers' professional identity (arrow 5); as well as classroom practice (arrow 6). Finally, enhanced professional identity may ultimately find expression in contributions to the external domain (arrow 9).

## METHODOLOGY

Searching for in-depth understanding of teachers' classroom practices requires an interpretative paradigm to enable the researcher to understand the situations and actions of teachers as viewed and experienced by the

**Table 1.** Overview of the themes and categories used for the analysis of interviews

Themes	Categories
Teacher's subject knowledge	Teacher's subject knowledge
Laboratory work	Practical skills
	Resource needs
	Improvisation
Pedagogical knowledge	Pedagogical skills
	Understanding learners
Learner outcomes	Learner outcomes
Professional identity	Teacher's belief
	Teacher confidence
	Teacher's attitudes
	Collaboration

participants. Therefore, a qualitative approach was chosen, employing a case-study design in the teachers' natural environment (Creswell, 2007).

The sample for the study was purposively selected, as is generally used for qualitative studies in order to ensure that participants meet predetermined criteria (Creswell, 2007). First and foremost, as the first author held office in a particular provincial Department of Education, a different province was selected for the study to ensure that issues of power relationships are avoided. To reduce travelling time and cost, a province relatively close to the first author's home was chosen. Teachers who have completed the ACE NS programme in a well-established, specific institution of higher learning were particularly targeted. The database of the teachers who completed this ACE NS programme and the profile of the schools were sourced from the Department of Education in the province. The list showed names of 28 teachers, all from schools in semi urban areas surrounding a large city. The first author approached the principals of the all relevant schools and found five teachers who were available and willing to participate. One of the teachers later decided not to continue. The principals and teachers were unknown to the researcher, ensuring that issues of power were not involved.

The participants completed the ACE programme two years prior to the study. The ACE programme was taught part-time over a period of two years. The programme included Natural Science content as well as pedagogy, offered as the following ten courses: Life and Living; Matter and Materials; Planet Earth and Beyond; Energy and Change; Curriculum in Context; Curriculum Development; Approaches to Learning and Teaching; Classroom Assessment; Learning and Teaching Science; Learning and Teaching Resources in Science. Detailed information about the ACE programme can be found from the Service Provider (Radmaste, 2013) as well as from the first author's PhD thesis (Kekana, 2015).

As indicated by Silverman (2014), for qualitative research, the researcher should have direct access to what is happening. In this study direct access to the classroom was realised by visiting teachers in their schools. Data were collected using interviews, observations and document analysis. Firstly, a semi-structured interview was conducted with each teacher; the interview protocol is available in [Appendix 1](#). The interviews were audio-recorded to ensure that no information was lost (Silverman, 2014). Secondly, for each teacher, six consecutive lessons were observed during a two-week period in the third term. The duration of lessons were about 40 minutes, amounting to a total of 16 hours of lesson observation for the four teachers. The teachers were asked to continue their normal routine during the observed lessons, following the curriculum as prescribed by policy, to ensure a natural classroom situation, rather than special lessons. A lesson-observation schedule was developed specifically for the study, based on important aspects of classroom practice described in the literature. The lesson-observation schedule is available in [Appendix 2](#). In particular, practical, pedagogical and language skills, subject knowledge, beliefs and attitudes were noted as the lessons progressed. Finally, the teachers' documents as well as learners' workbooks were analysed. Each teacher was asked to select three workbooks after completing the lesson observations; there was no particular instruction for how the books should be selected.

Qualitative content analysis was conducted, analysing each case separately. For the interview, categories were based on the literature and theoretical framework, and some emerged from the data. The transcriptions were initially coded by the first author, repeated by the second author and discussed to reach consensus where interpretations differed, thereby enhancing trustworthiness. Finally, the categories were grouped under the following themes: subject knowledge, laboratory work, pedagogical knowledge, learner outcomes, and professional identity, as shown in [Table 1](#). Lessons were analysed in terms of the observation schedule. Teachers' records and learners' workbooks were inspected to confirm evidence from other data sources, as suggested by Maree (2007). The schedule for document analysis is given in [Appendix 3](#).

The design of the study enhanced trustworthiness, using three data-collection methods to allow triangulation. To enhance credibility of data collected through lesson observations, six consecutive lessons were observed for each

**Table 2.** A part of Mr Wakithi's transcription including coding of his responses

<b>Excerpts from interview transcript</b>	<b>Category</b>
Researcher: Do you think that your classroom practice has changed?	Teacher's beliefs
Mr Wakithi: Ma,am, it has changed because now kids are more eager to learn science each and every day. Everyday learners do not want me to go out from their classroom sessions.	Learner outcomes
Researcher: What do you think is the best way for learners to learn science?	Teacher's confidence
Mr Wakithi: To make them aware that eh, without living organisms which are around us we cannot go anywhere. The environment, the ecosystem, go in pollution. I try to convince them that they must love nature like brothers and sisters.	Teachers' beliefs
	Pedagogical skills

teacher. Ethical research practices were followed to ensure that participants were not harmed physically and emotionally. Ethical clearance was obtained from the University and the Department of Education gave permission for data to be collected in schools.

## RESULTS

The participants are referred to by pseudonyms, Mr Wakithi, Mr Mashangura, Mr Zulu and Ms Ntombela. Each held a Senior Primary Teachers Diploma, while Mr Mashangura also held a two-year Further Diploma in Education. Ms Ntombela was the only teacher who had a science laboratory in her school while the other teachers had a few pieces of apparatus in their classrooms. Though all four teachers in this study believed that their classroom practice had changed for the better after completing the ACE programme, there were clear differences in how they perceived these changes.

The results are presented per participant, integrating the data from the different instruments, in order to gain in depth understanding of each participant's perspectives and practices. Each case is discussed in terms of the five themes identified from the literature.

### Mr Wakithi

Mr Wakithi presented four lessons on acids and bases, another lesson was used for assessment and the last was on introducing a new topic, 'energy'. Analysis of his interview showed that some responses often provided more information than asked for, and in such cases more than one code was assigned, as shown in [Table 2](#).

#### *Subject knowledge*

The lesson observations revealed that Mr Wakithi had sufficient knowledge to teach science in Grade 7. He explained that he learnt more during the ACE programme, referring to "... about the puberty age all in details", and "... more about the stars, some are gases some are liquids, there is one that is missing ...". Activities in learners' workbooks confirmed that he had adequate content knowledge, showing how learners' wrong answers were corrected. However, he mentioned that he needed more content knowledge about the 'Earth and Beyond' as well as about 'Matter and Materials' Natural Sciences knowledge strands.

#### *Laboratory work*

Mr Wakithi indicated that during the ACE programme they had opportunities to use apparatus they never used before, and that they had to perform experiments in front of colleagues. However, he believed that he still lacked practical competence in conducting experiments, saying: "I still need to improve and gain more practical skills. Hence I say I am not that good but I am trying." In spite of this, he successfully presented a demonstration and facilitated three practical sessions during the observation period, which indicated that he actually had adequate practical skills. In one of the practical sessions, he used some chemicals from the school's limited stock. He explained during the interview that he did not have sufficient apparatus and therefore he sometimes improvised. Improvisation was indeed observed when learners brought household substances which they tested for acidity.

#### *Pedagogical knowledge*

Mr Wakithi indicated that the ACE programme expected of teachers to make their "classrooms to be more friendly", and that they were "equipped with new strategies" and that learners need to "love science more". Teaching to care for the environment is demonstrated in his remark shown in [Table 1](#). He also mentioned that he learnt "the thing about hypothesising". He said learners who struggled to understand were assisted by using the strategy of group work; and that he used the "fast learners to assist those that are slow". Group work was indeed observed during the three practical lessons, but not in other lessons. Regarding language, he mentioned that some



**Table 3.** A part of Mr Mashangura's transcription including coding of his responses

<b>Excerpts from interview transcript</b>	<b>Category</b>
Researcher: Can you mention one science concept you think you learnt in ACE?	Laboratory skills
Mr Mashangura: Yes, oh, science concepts? Uhm, by doing experiments and by changing style of teaching, by doing experiments, investigations and also motivating learners to participate.	Pedagogical skills
Researcher: Can you give an example of subject knowledge in the syllabus that you struggle to teach?	Resources
Mr Mashangura: Eh! All I can say is acids and bases due to what? Lack of lab at the school.	

learners do not understand colours in their vernacular, "then you have to show them, they must see these colours ...". It was also observed that Mr Wakithi code-switched to explain to learners who struggled with English. He indicated during the interview that learners made use of a dictionary, and when necessary, he collaborated with other teachers who knew different languages.

### *Learner outcomes*

Mr Wakithi claimed that his learners enjoyed science since he completed the ACE programme, as illustrated by his remark in [Table 1](#). Later in the interview he elaborated, indicating that learner outcomes improved, saying "They now love this NS more than any learning area, because the results have improved dramatically since I completed ACE". Yet he later remarked that some learners were not co-operating: "... they write their homework in class, some they wait for you to give feedback and fill in work they were supposed to do at home."

### *Professional identity*

Mr Wakithi was confident when responding to questions and displayed a positive attitude towards the ACE programme. He indicated more than once that he learnt about "togetherness" of teachers: "The practice I learnt from ACE was this collaboration amongst ourselves." Not only did he mention that he sometimes asked for assistance from others, for example with practical work and language issues, but indicated that he was willing to contribute to the district cluster and that he aspired to be an examiner in the cluster. He added: "I can even see someone utilising my skills which I learnt from ACE." He displayed a positive attitude to teaching science, saying that he enjoys teaching more after completing the ACE. He referred to an incident in class where "I went an extra mile, I was going and going until I was stopped by another teacher" which revealed his enthusiasm and positive attitude. He explained that "the love of nature" is the best way for learners to learn science, revealing a wish to propagate a positive attitude to science. Overall, Mr Wakithi revealed that his professional identity was enhanced in terms of subject knowledge, practical competence, valuing collaboration and a positive attitude towards teaching science. By the end of the interview he indicated that teachers should be inquisitive and keep learning and sharing: "I have learnt as a teacher, not of science but a teacher in general. ... You must go and ask for more, you must share with other teachers. As I told you about the planets issue, some of us still think that there are nine planets while one is gone. You have to go deeper and seek more information. You must network as a science teacher."

### **Mr Mashangura**

Mr Mashangura presented four lessons on the separation of mixtures, one on forces and one on electricity, following the sequence prescribed by the curriculum. In his interview, his answers provided rich information, though not always focused on the questions, as illustrated in a section from the analysis shown in [Table 3](#).

### *Subject knowledge*

Mr Mashangura indicated during the interview that his subject knowledge has "definitely" improved during the ACE programme, though he did not mention specific topics or concepts. During the lesson observations, it was found that he presented and explained scientific content correctly. From the learners' workbooks, it was found that correct feedback was given to learners.

### *Laboratory work*

Mr Mashangura presented a series of well-planned practical sessions, supporting his claim that he learnt doing experiments and investigations during the ACE programme. He facilitated the sessions with confidence, engaging learners in hands-on activities. Learners worked in groups, making mixtures from substances they brought from home and later they separated these. Following up on the topic, learners collected trash from the school grounds and sorted it in another session. There was also a chromatography activity, where learners separated colours in ink. He improvised to demonstrate the separation of water and paraffin, using an empty bottle, upside down, instead

**Table 4.** A part of Mr Zulu's transcription including coding of his responses

Excerpt from interview transcript	Categories
Researcher: What do you think the University wanted you to learn from the ACE course?	Practical skills
Mr Zulu: You know ... they trained us more practical things, that we must apply because science is more practical, but it is difficult for us because of these challenges I have mentioned. We have overcrowding, lack of resources like laboratories, apparatus and all those things.	Resources
Researcher: How do you think your classroom practice was expected to change after completing the ACE program?	Teacher's beliefs
Mr Zulu: Ja, it does change on my side because I have learnt a lot about the practical part of science. I was not a fan before I attended the ACE. ...	Practical skills Teacher's attitude

of a separating funnel. In fact, he used improvised materials in all practical sessions except for a lesson on forces where he used magnets from the school's limited resources. In this lesson, he encouraged learners to handle the magnets to actually feel the forces of repulsion and attraction, in support of his stated belief that "touching and feeling" during practical work enable learning to take place.

### *Pedagogical knowledge*

Mr Mashangura indicated that during the programme he learnt to plan lessons, assess learners, motivate learners and change the style of teaching by doing experiments. Document analysis showed lesson plans in his files, confirming that he regularly planned lessons, using a template provided by the ACE programme. To help learners understand, he mentioned that he used teaching aids like diagrams and pictures as well as practical work. He claimed that his classroom practice had improved after completing the ACE programme, for example by referring to Vygotsky and social constructivism. In fact, the use of constructivism was evident in two consecutive practical sessions where learners first used familiar household substances to make mixtures, and had to separate these mixtures in the next lesson. Mr Mashangura displayed enthusiasm and patience during teaching. He clarified scientific concepts whenever the learners did not understand. For example, when he found that the learners gave incorrect answers during the lesson on attractive and repulsive forces, he repeated the explanations. He encouraged the learners to answer questions, to conduct hands-on activities, and to present their findings in front of other learners in the classroom. It was clear that he wanted his learners to participate, understand and enjoy science.

### *Learner outcomes*

Mr Mashangura believed that his learners' behaviour changed after he had completed the ACE programme, indicating that they want to understand science:

*"They want to concentrate ... in order to challenge the question asked in class and since they know in science we talk about true things, real things. You cannot say a child come from the ambulance, cannot say a child come from a river or aeroplane or ambulance. They have to understand that in reproduction the egg cell will meet the sperm cell."*

During observations, learners were co-operative and participated enthusiastically in the activities. The document analysis attested to this because the learners completed sufficient activities, as observed in their workbooks.

### *Professional identity*

Mr Mashangura displayed confidence and enthusiasm in the interview as well as during lesson observations. His beliefs about the value of engaging learners in practical work manifested in lesson presentation. This suggested that classroom practice improved in terms of improvement in his pedagogical knowledge, practical skills, confidence and enthusiasm to teach science.

### **Mr Zulu**

During the lesson observations, five of Mr Zulu's lessons were on the topic of 'Earth and Beyond,' and one was on mixtures. There were two practical activities conducted during the observation period. Mr Zulu often referred to the challenge of doing practical work due to the lack of facilities, as shown in [Table 4](#).

**Table 5.** A part of Ms Ntombela's transcription including coding of her responses

<b>Excerpt from interview transcript</b>	<b>Category</b>
<b>Researcher:</b> Can you explain how the ACE program has changed the way you view yourself as a science teacher?	Understanding learners
<b>Ms Ntombela:</b> Like I am brainstorming ACE. Other educators they must focus on various teaching methods. ... You can change the method. You can see like teaching grade 7A, B, C, D and E. On A the learners may understand more. You can change the method.	Pedagogical skills

### *Subject knowledge*

Mr Zulu displayed confidence, indicating that his subject knowledge "changed drastically" and later added "... now I am well equipped, I can answer any questions as far as science is concern". This belief was justified to some extent, as during the lesson observations, he presented and explained the scientific content correctly. The document analysis revealed that he gave learners correct feedback on the homework and classwork activities, indicating a sufficient command of subject knowledge.

### *Laboratory work*

He was of the opinion that the lack of apparatus limited his chances of practicing what he had learnt in the ACE programme, saying "... there is no problem as far as everything is concern in science, the only challenge that I have is experiment because here in our school we don't have a laboratory ...". He explained "I have to improvise practical so that they can be able to see". The lesson observations confirmed the data from the interviews because in the two hands-on activities conducted by the learners, the resources were brought by the learners from home; in one case they made volcanoes and in another case they separated mixtures. This improvisation indicates that he has adequate practical competence.

### *Pedagogical knowledge*

Mr Zulu indicated during the interviews that he planned his lessons using textbooks and the internet before teaching. He also said that he used different teaching strategies and that learners who struggle are given more activities while those who are "more intelligent" are given more challenging activities. Different teaching strategies were observed as he used demonstrations, presentations by learners, direct teaching, as well as incorporating group work. He also mentioned that he learnt "to allow learners to hypothesise, allow them to guess so that you can correct that guess thing".

### *Learner outcomes*

Mr Zulu was asked if his learners' behaviour in class changed after he had completed the ACE programme. He responded positively and further explained that previously, 60% of his learners obtained a "high mark", but after completing the ACE programme, he estimated it at "definitely 80 to 90". This indicated that Mr Zulu believed that his learners performed better.

### *Professional identity*

Mr Zulu indicated during the interviews that he was "excelling" as a science teacher after completing the ACE programme. He expressed confidence in teaching science and also indicated that he helped in training other teachers during district training sessions for the new curriculum. He also displayed confidence in the way he supervised the groups of learners during the practical sessions. Furthermore, he displayed a positive attitude towards the teaching profession when he honoured his appointment for lesson observation on a day when he was noticeably sick with influenza.

### **Ms Ntombela**

Ms Ntombela presented four lessons about 'Earth and Beyond', one lesson about mixtures and used one period to complete an assessment required by the school district office. She showed a lack of confidence during the interview, and gave mostly short answers. **Table 5** shows a section from the analysis of her interview.



### *Subject knowledge*

Ms Ntombela indicated that she had learnt subject knowledge during the ACE programme, especially about 'Matter and Material': "Like matter, I understand more matter, I did not understand before ...". It was noted during the lesson observations that she was comfortable teaching from the textbook or from the notes, but not confident in teaching without referring to these.

### *Laboratory work*

With regard to practical skills, Ms Ntombela indicated in the interview that she did not have sufficient practical skills to conduct experiments with learners. She also said that the laboratory was too far away and fetching apparatus wasted teaching time. During the six lesson observations, there were no experiments conducted, despite the fact that her school had a laboratory. In contrast to these remarks there was evidence that indicated that practical work actually did occur. There was an event where she allowed the learners to build circuits while she completed an administrative task during the lesson observation period. This suggested that the learners were actually familiar with the apparatus. Furthermore, the learners' books did show written work on some experiments conducted earlier in the year, suggesting that she actually did include practical activities as part of teaching. During the interview, when asked which experiences she thought enable learners to learn science, she responded, "I use science equipment, science equipment", which also suggests that she sometimes does conduct laboratory work. The conflicting data made it difficult to draw a conclusion about Ms Ntombela's practical competence. It is possible that she avoided practical work during the lesson observations due to a lack of confidence.

### *Pedagogical knowledge*

During the interview, Ms Ntombela indicated that she used different teaching methods to accommodate learners with different learning styles. In answering another question, she also mentioned that "you can change the method", similar to her response shown in [Table 4](#). She also claimed to use visual aids like charts and posters to support learning. This was actually observed in the second and sixth lessons. Across the six lessons that she presented for observation, it was found that she mostly used direct teaching from the textbook and notes, oral questions and having learners reading aloud all together.

### *Learner outcomes*

Ms Ntombela was asked about the learner outcomes, and indicated the learners enjoyed learning when she was "active", which seems to contradict her claim that she does not use practical work in lessons. She mentioned that there were still learners who were not well behaved, and during the lesson presentation she spent approximately ten minutes reprimanding learners on one occasion. Apart from the learners who were not cooperating, the analysis of the learners' workbooks revealed that they regularly did homework and classwork.

### *Professional identity*

Ms Ntombela's files and learners' workbooks indicated that she worked according to the departmental schedule. She indicated that she attends and enjoys cluster meetings and that the ACE programme contributed to develop her content knowledge. However, the interview and lesson observations revealed that she lacked confidence in her subject knowledge and her practical skills. Furthermore, her teaching style and reluctance to present practical lessons suggested a negative attitude toward science teaching. It seems that the ACE programme did not develop her confidence or attitude to provide positive learning experiences for her learners.

## DISCUSSION

To be able to understand and explain the teachers' classroom practices, lessons were observed, documents analysed and teachers were interviewed. The results indicated that classroom practices of Mr Wakithi, Mr Mashangura and Mr Zulu were indeed enhanced in terms of improved knowledge and practical skills, enjoyment of the programme, enhanced confidence and positive attitudes, as well as improved learner attitudes. It was also clear that the need for resources inhibited the improvement of classroom practice of these three teachers.

The results of this study should not be generalized, as it was a case study, searching to understand if, how and why these teachers' classroom practices changed following the professional-development programme. It should be noted that teachers' perceptions of their own practice and learners' outcomes may be misleading, creating an exaggerated impression of positive attitudes. However, the observation of six consecutive lessons for each teacher as well as analysis of learners' workbooks and teachers' files provided information about actual practice to enable

the researchers to form a holistic understanding of each teachers' individual experience and practice. Altogether, results clearly showed that this professional-development programme did not produce optimum outcomes for the teachers who participated in this study.

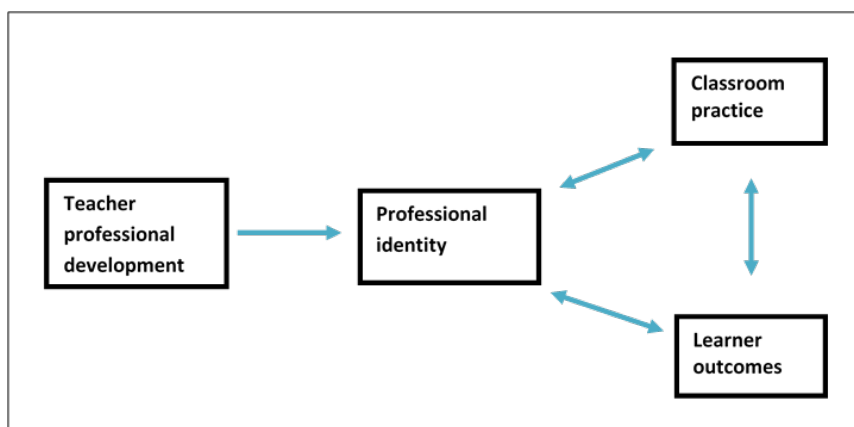
Three of the four participants were restricted by the lack of resources in their schools in implementing some of the knowledge and skills learnt. This is in agreement with Darling-Hammond et al.'s (2017) argument that lack of resources is a factor that can render a professional-development programme ineffective. Similarly, Buczynski and Hansen (2010) found that teachers struggled to implement knowledge and skills learnt in a professional-development programme. However, the ways in which teacher professional development occurred depends on the unique personalities and circumstances of the teachers. Confidence and positive attitudes to teaching seemed to enable three of the four teachers to grow as professionals. This is in agreement with what Borko's (2004) conclusion that teachers responded to professional development differently, claiming "some teachers change more than others through participation in professional-development programme".

The ACE programme did not fully develop the commitment of teachers to conduct practical work consistently. The analysis of documents revealed that most practical activities were conducted during the data-collection period, in fact, very little practical work was conducted during the semester prior to data collection. This may be an illustration of the Hawthorne effect (Wickström & Bendix, 2000). Therefore, it is possible that the practical work presented by three of the teachers during the study may gradually regress after the study (Leonard & Masatu, 2006). On the other hand, the experience of successfully improvising during the study may have good long-term results. It is argued that teachers in the current study may have realised their potential of conducting practical work when they were observed and they may be inspired to continue the practice. Furthermore, there was little indication of any direct implementation of what was learnt in the programme, except for one example where Mr Mashangura used the lesson plan template provided during the programme. Instead, the views expressed by the teachers indicated that changes in classroom practice were mainly caused by the changes in their professional identity.

According to the theoretical framework, improved classroom practice and improved professional identity both lead to improved learner outcomes. Although learner outcomes were not directly investigated, the views expressed by the teachers suggested that there had been an improvement in learner outcomes. It was not only the classroom practice that influenced learner outcomes but also the effects of enhanced professional identity. For example, Mr Wakithi reported that learners were more eager to learn science and ascribed it to his improved confidence. Therefore, results suggested that improved learner outcomes resulted from changes in classroom practices as well as professional identity. According to the theoretical framework, a professional-development initiative impacts on classroom practice by direct implementation, as well as indirect processes of enactment and reflection involving professional identity and learner outcomes. In the current study, little indication of direct implementation of the programme was found, contrary to Guskey's (2002) model. Rather, it was enhanced professional identity that contributed substantially to the growth of classroom practice, in agreement with Desimone (2009). Reverse processes were also found, indicating that the improved learner outcomes reinforced growth in classroom practice and teachers' professional identity.

## CONCLUSION

The results lead to a revised model of professional growth that represents professional development of teachers in poorly resourced schools where direct implementation is obstructed by lack of resources. This model is shown in [Figure 2](#). On the whole, in this model, science classroom practice and learner outcomes are observable outcomes of a professional teacher-development programme but these outcomes are the product of changes in professional identity, rather than from direct implementation. In addition, there is a positive feedback effect from improved learner outcomes reinforcing classroom practice and professional identity.



**Figure 2.** A suggested model of teacher development in poorly resourced schools

Although this was a case study, results support literature with regard to challenges regarding implementation of what was learnt in a professional-development programme. It is therefore recommended that in future programmes, support, including resources, should be provided to teachers after completing a teacher-development programme to re-enforce and implement new skills. Further research should be undertaken to investigate the applicability of the new model in other contexts.

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## APPENDIX 1

## Interview Protocol

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1. Do you believe that you have sufficient subject knowledge to teach the syllabus? (If yes: Can you give an example of subject knowledge in the syllabus that you struggle to teach? If no: Are there any topics you struggle to teach?)

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  2. Do you believe that you have sufficient practical skills to do the prescribed experiments? (How often do you do experiments with learners; do you have enough apparatus to conduct experiments, If no, what is needed? Do you sometimes use improvised materials to do experiments? If Yes, can you give an example)

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  3. How do you plan lessons? (Can you name information sources you use to plan/prepare for each lesson?)

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  4. How do you decide which learning activities and instructional materials to use in a lesson (What do you do when learners are struggling to understand what you are teaching them)?

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  5. How do you accommodate learners with different learning styles?

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  6. How do you help learners to understand science when they have difficulty to understand the language?

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  7. What kinds of experiences do you think enables learners to learn science? (What do you think is the best way for learners to learn science?)

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  8. What do you think the department of education wanted you to learn from the ACE programme?

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  9. What do you think the university wanted you to learn?

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  10. How did you think your classroom practice was expected to change after completing the ACE program?

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  11. Do you think your classroom practice has changed? (If yes, which way? If no, what prevents you from changing your practice?)

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  12. Do you think your subject knowledge has improved? (If yes, can you name one science concepts you think you learnt in ACE? If no, why do you think you did not learn anything from ACE?)

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  13. Can you tell me about something you were taught in ACE which you are practicing in class? (Can you mention any best practice or experience you copied from ACE and you are implementing in class?)

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  14. Did your learner behaviour in class changed since you completed ACE? (If yes, in which way? If no, why do you think it did not change?)

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  15. Do you think learners are now enjoying science when you teach now that you completed ACE? (If yes, can you explain why do you think they are enjoying? If no, what prevent them from enjoying?)

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  16. Did you enjoy the ACE programme? (Can you name a specific concept that you enjoyed about ACE programme?)

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  17. Do you enjoy teaching science more than before you completed the ACE programme? (Can you mention a specific thing you enjoy in teaching science?)

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  18. Do you have more confidence in teaching science after completing the ACE?

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  19. Can you explain the effect of your learners' responses on your new classroom practice?

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  20. Would you be willing to share what you learnt in ACE in the cluster meeting? (Can you explain how the ACE NS programme has changed the way you believe and view yourself as a science teacher?)
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APPENDIX 2

Lesson Observation Schedule

Elements of classroom practice to be observed	Question guiding observation
Teachers' subject knowledge	Is the content presented correctly?
	Is the content explained adequately?
	Does the teacher relate what he taught to real life examples?
	Is the teacher able to respond to learners' questions correctly?
Teachers' practical competence with experiments	Did the teacher select appropriate apparatus beforehand?
	Was the experiment suitable for Senior Phase? (comment on the relevancy of the experiment to the curriculum)
	Is the purpose of the experiment clearly stated?
	Were apparatus checked beforehand for functionality?
	Was there a worksheet or guideline on what to observe?
	What was the source of the worksheet or guidelines?
	Were learners clarified as to what to write on the worksheet?
	How was the practical work assessed or the experiment assessed?
	Did learners perform hands-on practical work?
	Did the teacher conduct practical demonstration?
	If it was a demonstration, was it visible to all the learners? Explain how
	What were the learners expected to do after seeing the demonstration?
	Were the learners assessed to find if they have learnt something from the demonstration?
Pedagogical skills	Is there continuous assessment?
	How is the classroom managed?
	Does the teacher link content to learners' previous knowledge and context?
	How is the interaction of the teacher with learners?
	How is learner participation, are they actively involved?
	Is there evidence of cooperative learning?
	Does the teacher use models/visual examples to explain science concepts?
	Are the various learning styles of learners accommodated in the lesson?
	Is the teacher aware of learners' typical misconceptions?
	Does the teacher use different strategies to teach? Which?
	Does the teacher ask learners questions that cater for the different cognitive levels?
Language skills	How much direct teaching does the teacher use?
	Does the teacher use the discrepant event to clarify further for learners?
	Do the planned learning activities accommodate language skills?
Teachers' beliefs and attitudes in teaching science	Does the teacher code switch appropriately?
	How confident is the teacher in teaching science?
	How is the enthusiasm of the teacher?
	Does the teacher inspire the learners?

## APPENDIX 3

### Document Analysis Guide

#### Learners' workbooks

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**CRITERIA**

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Activities based on practical work

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Frequency of written work

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Accuracy of feedback or corrections given to learners by the teacher;

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Activities that require high order thinking

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Evidence of various forms of assessment given to learners

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#### Teacher documents and records (Work Schedule, lesson preparation and programme of assessment)

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**CRITERIA**

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Activities in teacher planning that involve practical work

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Science content covered for the grade in the planning

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Learners assessment records, planned for various learning styles

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Recording sheets for the learner performance

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<http://www.ejmste.com>