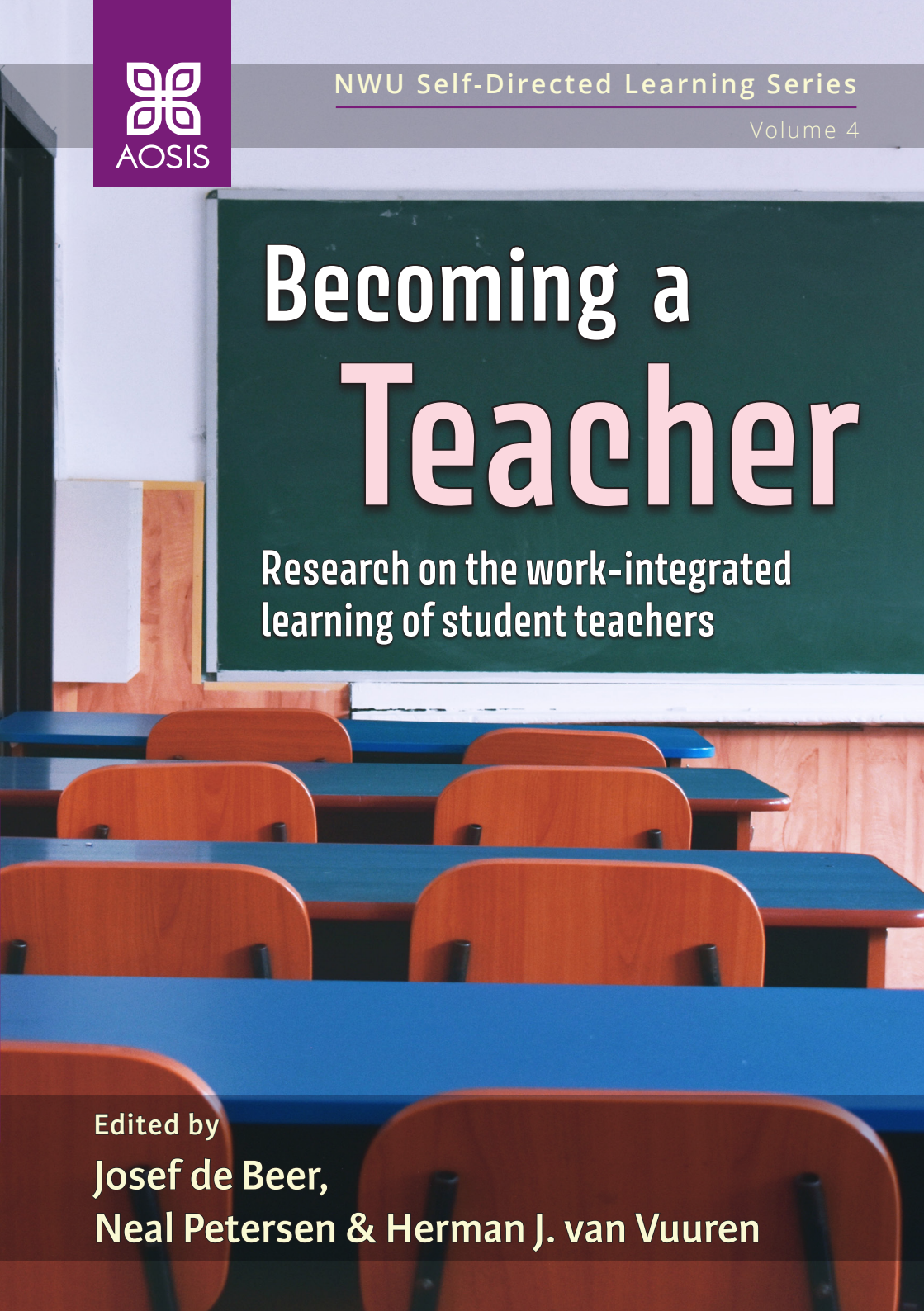
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Chapter 11

A hybrid model building on prolepsis for effective practice teaching in pre-service life sciences teacher education

Josef de Beer
Research Unit Self-Directed Learning,
Faculty of Education, North-West University,
Potchefstroom, South Africa

Sarah Gravett
Office of the Executive Dean,
Faculty of Education, University of Johannesburg,
Johannesburg, South Africa

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Abstract

The need for this research is substantiated by two sets of research literature, namely, literature that belabours the so-called 'theory–practice divide' in teacher education and, secondly, literature on the dismal state of science education in South Africa. This chapter critically looks at the pre-service education of life sciences student teachers and reports on an intervention that was conceptualised and implemented by the UJ to address some of the shortcomings of the customary school practice experience (or WIL).

Teacher education institutions are often criticised as being distant from practice and therefore ineffective in preparing student teachers for the demands of the teaching profession. This is especially true in the teaching of the natural sciences (including life sciences and physical sciences) – a national priority in a country that is not performing well in international benchmark tests. This chapter reports on an innovative intervention of the UJ whereby undergraduate student teachers were given the opportunity to teach life sciences (FET Grades 10–12) to learners from a top-performing school that did not offer life sciences as a subject. The authors will indicate how this intervention addressed three fundamental problems associated with learning to teach, namely, (1) the problem of the apprenticeship of observation; (2) the problem of enactment and (3) the problem of complexity. This qualitative research focussed on how this intervention contributed to the 81 student teachers' (who participated) professional development. The Japanese lesson study approach, where student teachers prepared and presented lessons in groups of four, were further enhanced with the technique of prolepsis, which involves structuring learning opportunities in a way that assumes that the student teachers know more than they actually do. By using such a prolepsis approach in teacher education, the teacher educator can explore the optimal distance between the student teacher's actual and potential development. This intervention differentiates itself from the usual school

experience, in the sense that the pre-service student teachers became the actual teachers who took sole responsibility for the learning activities over a full academic year. Data were collected through personal and FG interviews, classroom observations, questionnaires and studying artefacts (e.g. student teachers' lesson plans and written reflections). This authentic immersion in teaching, linked with effective mentoring, holds affordances for the effective education of life sciences student teachers.

Keywords: Pre-service teacher education; Prolepsis; Inquiry learning; Zone of proximal teacher education; Mentoring.

Science teacher education in South Africa: Can the phoenix rise from the ashes?

South Africa has unfortunately performed dismally in the past decades in terms of school learners' performance in science and mathematics (De Beer 2016). News 24 (2014) in an article described South Africa as having the 'worst maths and science education in the world'. This was in response to a report by the World Education Forum (WEF), in which South Africa was ranked last out of 148 countries in terms of science education. Most academics would warn that the WEF is not a reliable source, as the study relies heavily on perceptions. However, the research of Molapo and Pillay (2018), Simkins (2010) and Spaull (2013) highlighted similar negative sentiments. Simkins (2010) indicated that:

> … 90 per cent of our schools are still failing to meet the minimum performance standards in mathematics and science education, thus undermining the potential of millions of young South Africans. (p. 12)

Many reasons have been provided for this dismal performance in science education: under-qualified teachers, qualified teachers without the necessary PCK or understanding of the tenets of the nature of science (De Beer & Petersen 2016; Motambatamba 2018), lack of laboratory equipment, constant changes to the school curriculum and the lack of a full CAPS, to name but a few

(Cronje 2015; De Beer & Ramnarain 2012; Sebotsa, De Beer & Kriek 2019). Spaull (2013:5) indicated that many teachers have below-basic levels of content knowledge. Teachers are also struggling to contextualise science for learners, and in an era of the 'decolonisation of the curriculum', this is an important issue to address in teacher education (De Beer & Petersen 2016; ed. De Beer 2019). In an attempt to address the above, the question that TEI in South Africa should ask is whether they optimally prepare student teachers for the challenges that they will encounter in the science classroom, and whether the graduate teachers who would act as agents of change. In this section, we first highlight a few specific problems related to teacher education in general, and then we focus specifically on challenges in the education of science teachers.

Darling-Hammond (2006) and Scherff and Singer (2012), taking a more international stance on pre-service teacher education, identified three fundamental problems associated with learning to teach, that is, of particular concern in South Africa, especially in the natural sciences:

1. Firstly, student teachers often mimic the teaching methods and behaviour of the teachers that they had when they were pupils – Lortie's (1975) so-called apprenticeship of observation (refer to Ch. 7 for a comprehensive discussion of this construct). This results in the unfortunate situation that teacher educators do not always sow on fertile grounds in teacher education – student teachers do not always accommodate new theoretical perspectives in their development of personal teaching philosophies.
2. Student teachers should not only learn to think like teachers, but they should also act like teachers, which does not necessarily happen. This is what Kennedy (1999) calls the 'problem of enactment'.
3. Teaching is complex. All teacher educators will concur with Shulman (2004:504) that 'classroom teaching is the most complex, most challenging, and most demanding and frightening activity our species has ever invented'. Learning to

> teach requires student teachers to understand the complexity and multi-faceted nature of classroom teaching – an aspect that Jackson (1974) calls the problem of complexity. One of the challenges facing the teacher educator is to change the often naïve viewpoints of student teachers (Petersen & De Beer 2019).

These three fundamental problems are of course also applicable to the education of life sciences student teachers. The mimicry of the teaching methods that they were exposed to as learners is especially a big concern. Science education in South Africa is trapped in transmission-mode practices (De Beer & Ramnarain 2012; Motambatamba 2018; Ramnarain & Schuster 2014). Hailman (1975) argued four decades ago that 'the approach to the "scientific method" in schools was often just as detached from how an Einstein functioned as the colour-by-number sets are removed from Michelangelo's painting technique' (De Beer 2012:324). Several studies have shown that natural-, physical- and life sciences classrooms in South Africa are characterised by transmission-mode teaching, with limited learner engagement, and where practical work is done, it is often characterised by 'cookbook' approaches and limited inquiry (De Beer & Ramnarain 2012; Sebotsa et al. 2019). Cronje (2015) and Motambatamba (2018) have also shown that science teachers often have naïve understandings of the nature of science, and this negatively impacts on inquiry pedagogies. This is currently one of the biggest problems in science education in South Africa, and it should be addressed by focussing on teacher professional development on both in-service and pre-service levels. Unfortunately, as we will show later, the customary school practice that student teachers engage in often does not address this adequately. Research (Cronje, De Beer & Ankiewicz 2015; De Beer & Ramnarain 2012; Motambatamba 2018) shows that teachers often have underdeveloped understanding of the tenets of science. This negatively impacts on the teaching of science in which science is portrayed as empirical but creative, exact yet subjected to change, etc.

Alternatives to the traditional school practicum

Universities are often criticised for not sufficiently preparing student teachers for the complexity of the teaching profession. Levine (2006:35) noted 'that the field of teacher education is in a state of disarray in the United States of America (USA), reflect(ing) (its) historic confusion with regard to purpose'. Korthagen (2001), writing from a European perspective, said that many politicians, teacher educators, student teachers and graduates are dissatisfied with teacher education. In England, dissatisfaction of politicians has resulted in the transfer of a considerable part of teacher education to selected schools (Mcnamara, Murray & Jones 2014). The 'theory–practice divide' in the education of teachers seems to plague teacher education (Gravett et al. 2016; Holland, Evans & Hawksley 2011; Laverty 2006). Teacher education institutions implement various strategies to address the perceived theory–practice divide, the most common being establishing partnerships with schools, and placing student teachers in such schools for the school practicum component of the teacher education programme. Two models in which schools play prominent roles in the education of teachers are PDSs in the USA (Abdal-Haqq 1998; ed. Darling-Hammond 2005; Gűven 2010) and teacher training schools in Finland (Loukomies, Petersen & Lavonen 2018; Tuovinen 2008) and recently also in South Africa (Gravett 2015; Gravett & Ramsaroop 2017). However, the most prominent model that prevails worldwide is placing students in a variety of schools for specified periods with little direct collaboration and dialogue between university-based teacher educators and school-based mentors of student teachers.

University staff visits to the schools are often limited to observing a few lessons presented by student teachers. This model often makes it difficult to sufficiently address the three fundamental problems listed earlier, namely, the problems of apprenticeship of observation, enactment and complexity – especially in breaking the transmission-mode teaching cycle and introducing problem-based inquiry learning. Mentor teachers in

many schools also do not adequately support student teachers in their professional development.

In this chapter, we report on an intervention that addresses the shortcomings of the traditional school practicum involving a partnership between a university and a secondary school. The school in question did not have the means to offer life sciences as a subject option in grades 10–12 though there was interest from learners to pursue this subject. We saw the opportunity at the UJ to assist the school with this need and to simultaneously introduce a school practicum programme at the school that will benefit the university's life sciences student teachers in their development as teachers. To do this, we introduced an intervention in which senior undergraduate student teachers (fourth-year BEd and Postgraduate Certificate in Education [PGCE] students) took responsibility for teaching life sciences to the school learners, supervised and mentored by teacher educators. In this chapter, we report on a qualitative study that was conducted to explore the affordances of this intervention for student teachers' professional growth over an academic year. We first describe the intervention and then present the findings.

The school practicum intervention

Background: Why this intervention?

The authors, having been involved in teacher education for decades, became increasingly concerned about the inability of the conventional school practicum sessions to often scaffold student teachers in using problem-based and inquiry learning approaches in the natural sciences. The UJ was tasked to lead research on the feasibility of TSs in South Africa, and this specific intervention formed part of this research. (In Ch. 4, the focus is on a TS in Soweto associated with UJ). In 2013, when this intervention was introduced, a group of 26 student teachers collectively took responsibility for teaching 12 Grade 10 life sciences learners for a full school year. In 2014, a new cohort of 25 Grade 10 learners was taken in (and the Grade 10 learners of the

previous year – all 12 – progressed to Grade 11). A new group of 55 student teachers signed up for the intervention in 2014 and again taught the learners for a full year. This chapter therefore reports on the experiences of 81 life sciences student teachers who participated in this intervention. In both years, the student teachers were divided into teams of four, and each team was assigned to either teach in Grade 10 or in Grade 11. The year 2015 earmarked the third year of this intervention (with the first cohort of Grade 12 learners), but only data from 2013 to 2014 are reported on in this chapter.

The approach: Scaffolding learning across a zone of proximal teacher development

Both authors subscribed to some aspects of Vygotskyan notions of learning, and the intervention was conceptualised around scaffolding student teacher learning across a ZPD (Vygotsky 1978) or, as explained later, across the ZPTD (Warford 2011). The student teachers took full responsibility for the teaching, implying that they planned lessons according to the official curriculum, and pacesetters provided by the South African DBE presented the lessons, monitored learner progress, identified learning needs, conducted the assessment and reflected on the teaching and learning. There was also a research component involved, with the student teachers having had to engage in classroom action research (e.g. student teachers had to conceptualise, implement and research a 'science-on-a-shoestring' intervention, where they had to foster open inquiry using low-cost materials).

The process followed during the intervention

The intervention was based on the Japanese lesson study model. Lesson study is a professional development process, focussing on enhancing critical reflection of teachers, in order to improve lessons. It is characterised by its collaborative, cyclical and continuing nature (Chikamori, Ono & Rogan 2013). This innovation

is a well-established classroom-based and collaborative form of teacher development that is used by Japanese teachers to systemically examine their practice in order to become more effective teachers (Fernandez & Chokshi 2002). In our intervention, the teams of student teachers designed lessons together, and these were discussed, involving the teacher educators, a few days prior to the day that the lesson was presented. The role of the teacher educators was to assess the student teachers' lesson plans and to provide suggestions for improvement. Problems that emerged during the delivery of the lesson were ascribed to the team and not to the student teacher who taught that particular section (Stigler & Hiebert 1999). Student teachers also took responsibility for arranging the practical work sessions. In Figure 11.1, we explain the cycle.

A problem that we experienced at the beginning of the intervention was the lack of continuity. Student teachers would often teach, without having a good understanding of what content was dealt with during the previous class. (Student teachers followed a timetable, and each group got a turn every 4–6 weeks.) We therefore realised that we needed to ensure that a group of student teachers who were teaching should at least knew what had been taught in the previous classes. We therefore implemented a system which involved two groups of student teachers every week: the incoming group and the teaching group. The incoming group observed the lesson and assessed the teaching group's lesson using a rubric. This served as a valuable learning experience for them and ensured continuity because the incoming group was again the teaching group in the week that followed. Each lesson presentation was followed by a reflection session, during which both student teachers and teacher educators reflected on the lessons.

Student teachers' involvement in a particular lesson was preceded by planning meetings (with the teacher educators), and after the lesson, a reflection session. One cycle of a team's involvement ran over a two-week period, as illustrated in Figure 11.1.

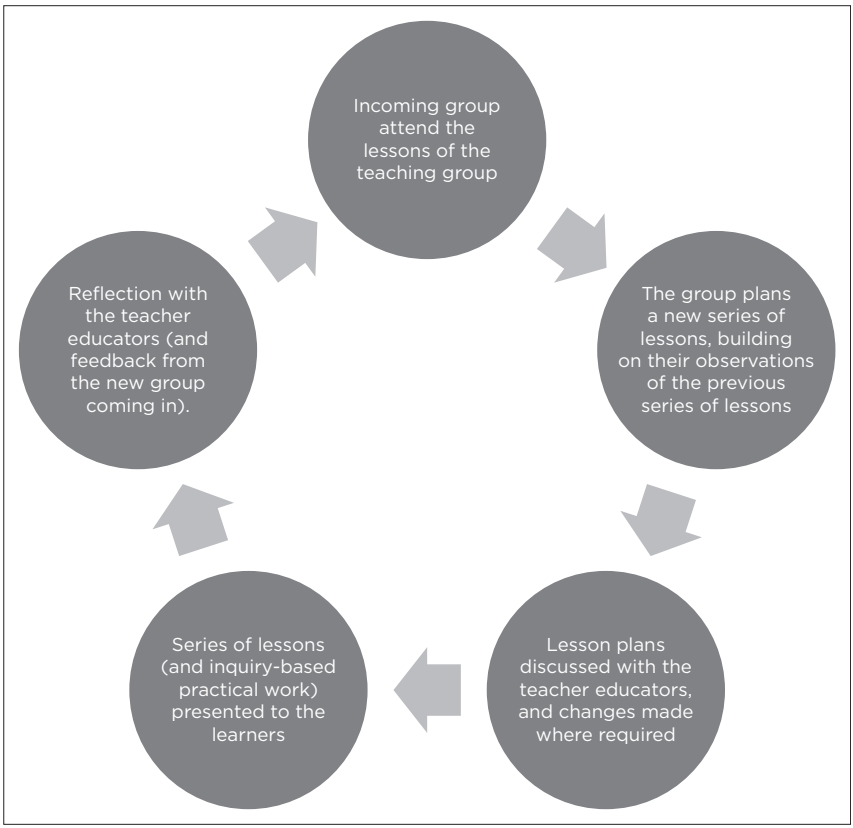

FIGURE 11.1: The life sciences intervention cycle.

A team of student teachers planned the lesson (emphasising inquiry-based learner activities) and then scheduled an appointment with the teacher educators. The latter provided feedback and suggestions on how the lessons could be improved, and the team of student teachers then went back to the drawing board and improved the lesson plans. A second meeting with the teacher educators followed and final changes were made to the lesson plans. The student teachers also had to take responsibility for obtaining all media used during the lesson, as well as for

arranging practical work in the laboratory. The concept of *Homo ludens* (the playing human) (Huizinga 1955) was emphasised – apart from inquiry laboratory approaches, student teachers were constantly reminded to utilise approaches that actively engaged learners in the classroom, including a pedagogy of play. After the lesson, a reflection session took place. In this session, the student teachers engaged in self-reflection on their lessons and the teacher educators and incoming group of student teachers provided feedback.

The class of student teachers collectively set the examination papers and all student teachers joined learners on excursions. Student teachers also engaged in classroom action research, for instance, in adopting science-on-a-shoestring approaches, or 'frugal science' (Jackson, De Beer & White 2018), with a view to develop agency. (Science teachers often complain that they do not have the resources to follow inquiry-based approaches, and in our view, student teachers should be taught to improvise, using everyday materials to teach in a more inquiry-based fashion.)

Prolepsis

Apart from the lesson study approach discussed above, the intervention is also characterised by prolepsis, a technique whereby a learning opportunity is 'structured in a way that assumes that the students know more than they actually do' (Van Lier 2004:153). By using a proleptic approach in teaching, the teacher educator can explore the optimal distance between the student teacher's actual and potential development (Van der Walt & De Beer 2016:559). Prolepsis foresees the internalisation of concepts that still need to be attained. Van Lier (2004:153) explained that '... prolepsis consists of attributing intent before its true onset, and capitalising on incipient skills and understandings as they show signs of emerging'. In this intervention, student teachers were emerged in authentic teaching, before they had been exposed to much educational theory. When they started to teach in this intervention, they had very limited exposure to theoretical lenses.

Research methods

This is a generic qualitative study. The research questions that guided this research intervention were:

- How do student teachers view their own professional development during this intervention?
- How do teacher educators view the professional development of the student teachers through their involvement in the intervention?

Data were collected over a period of 2 years through interviews with individual student teachers and teacher educators, FG interviews, reflective essays of student teachers (and their autobiographies), a questionnaire with open-ended questions and classroom observation (utilising the Reformed Teaching Observation Protocol [RTOP] instrument, of Sawada, Piburn & Judson 2002). In total, 81 student teachers were involved in the study over two years. All interviews were transcribed and coded, and a number of emerging themes were identified. Lesson plans and the RTOP questionnaires were analysed utilising a rubric as suggested by Cronje (2015) for the tenets of the nature of science, for example, whether lessons portray elements such as the empirical and the inferential nature of science. Analysis of the rich data has led to findings that are explored in this chapter through descriptive metaphors that students have used to describe their development as life sciences teachers in this intervention (De Beer, Lautenbach & Batchelor 2013:571). A brief discussion of the four themes that emerged from the study is provided. Because of the large number of student teachers in this course (n = 140 in 2014), not all student teachers could be accommodated in the intervention, and this resulted in useful experimental (n = 55) and control (n = 85) groups (for 2014). Although the comparisons between the experimental and control groups are discussed in another publication, we briefly summarise the findings in this chapter. After having analysed the data, we realised that the findings are well aligned with the stages that

Warford (2011) described during student teachers' scaffolding within the zone of proximal (teacher) development. We include a section where we provide the reader with a glimpse of how the professional development of student teachers occurred during the course of an academic year.

Ethical considerations

Student teachers were made aware that participation in the project is voluntary, and that they could withdraw from the research at any stage without any negative consequences. Furthermore, they were assured that pseudonyms, and not their real names, would be used when disseminating the findings.

The findings: The affordances of such a novel approach to pre-service teacher education

We discuss the findings under three headings. We will firstly look at the four main themes that emerged from the study. Next, we will look at how the professional development took place through scaffolding across a ZPTD, utilising the construct of Warford (2011). Lastly, we compare the student teachers who participated in this intervention, to those who did not participate in the intervention (all registered students in the life sciences methodology module).

The findings: The main themes that emerged

There were *four main themes* that emerged from the data, which we will briefly discuss. (More data supporting these themes will be provided in 'The findings illustrate student teacher learning across the zone of proximal teacher development' section).

The intervention assisted student teachers in replacing transmission-mode teaching approaches with more engaging pedagogies

When the intervention started at the beginning of the academic year, most of the lessons provided evidence of transmission-mode ('chalk and talk') pedagogies. Student teachers relied heavily on extensive PowerPoint slides, with little learner engagement (De Beer 2017:20). In spite of such uninspiring lessons that did not engage learners sufficiently, student teachers generally communicated contentment and *expressed their satisfaction* with the lessons during the reflection sessions (De Beer 2017). This made us realise that many student teachers are used to this type of transmission-mode lessons (the apprenticeship of observation).

At the start of the intervention, we were surprised by the student teachers' lack of sensitivity towards contextual factors and the ignorance about the fact that a teacher needs to know his or her learners, their attributes and contexts (De Beer 2017). An example was a lesson on biotechnology, during which the student teacher discussed traditional healing practices. As most of the learners were of Indian descent, and predominantly Hindu or Muslim, one would have expected more culturally applicable examples (e.g. Ayurveda practices) in the lesson. However, the student teacher exclusively focussed on African traditional healing, and sangomas (and the metaphysical activities of such African medicine people, e.g., making contact with the ancestors were unfamiliar to the learners) (De Beer 2017). The student teacher should have rather asked the learners about their own cultural traditional medicine (e.g. Ayurveda) and then introduce African traditional methods (De Beer 2017).

Gradually, as the school year progressed, there was evidence of transformed teaching practices, and the 'chalk and talk', transmission-mode lessons were replaced by lessons where SDL, PBL and engaging CL were emphasised (De Beer 2017).

The following lesson observation notes (made by one of the teacher educators) provide evidence of this fact (De Beer 2017):

> Well prepared lesson. Sabelo sort of took the lead, very confident. They didn't only lecture but used interactive learning, doing activities that involved the learners throughout. Sabelo used the learners as models to show the different layers of tissue in a plant. The learners remembered this well and when Janita recapped the lesson they still remembered it. Sabelo used different narratives to help learners remember the different tissues. The power point lesson was well planned and the practical work with the wet mounts went well. The whole team assisted with the practical work (Teacher educator, undisclosed gender, date unknown). (p. 11)

Feedback by a teacher educator on another lesson (cited in De Beer 2017) was:

> 'Wow, this was an excellent inquiry-learning lesson, where the student teachers did not provide "recipes" to follow, but the learners had to design experimental procedures to solve the problem. The team of teachers provided excellent scaffolding to the groups of learners, and the body language of the learners convinces me that the learners enjoyed the learning activity' (Teacher educator, undisclosed gender, date unknown). (p. 11)

The intervention provided student teachers with more nuanced understandings of the nature of science

A similar pattern, as described above, was also observed in terms of the realisation of the nature of science in lessons. At the beginning of the year, student teachers paid lip service to the tenets of science. As the year progressed, lessons were built around the true nature of science, displaying its syntactical nature. One of the student teachers reflected on this intervention (cited in De Beer 2017):

> 'What I've realised with school experience, is that teachers don't do practical work at all and if they do practical work its always sort of "cook book" activities that serve to confirm. In this project we were taught something that we don't learn during school experience: how

> to arrange good inquiry labs'. (Student teacher, undisclosed gender, date unknown)

In a similar vein, another student teacher commented (cited in De Beer 2017):

> 'I came to realise that the issue is to teach for maximum learner understanding – and not to simply cover the curriculum. And I realised what role inquiry approaches can play in fostering learner understanding'. (Student teacher, undisclosed gender, date unknown)

Another comment of a student teacher indicates an appreciation for the tenets of the nature of science (cited in De Beer 2017):

> I could see how the class became alive when we did inquiry activities. I realised that I have to provide learning opportunities in my class one day, that will give my learners a good sense of how a scientist operates. Something of the excitement and messiness of science should be captured in my classroom. (p. 21)

One of the teacher educators provided the following feedback on one of the observed lessons (cited in De Beer 2017):

> 'Tenets such as the empirical and inferential nature of science were centre-staged in this lesson. There was a definite "energy" in class, where the learners investigated the problem as scientific sleuths'. (Teacher educator, undisclosed gender, date unknown)

Student teachers' professional developments were scaffolded through the mentoring of peers and teacher educators

Student teachers commented on the good mentoring that they experienced in this intervention, in contrast to the poor mentoring and lack of support by mentor teachers in schools, during school experience (De Beer 2017):

> Most of the time the mentors at the school where we are teaching don't give support to the student teachers. You just ask them what are you going to teach and they tell you and that's it. You have to see for yourself how you are going to deal with the activities,

> they don't even ask where you are. You just teach and when the time comes to leave the school they would ask you where did you end. You show them what you did and that's it. They never come to class to check on you and to see how you are doing. They just don't care about their kids and student teachers. There is no support at all. (p. 21)

It was encouraging that some of the student teachers developed a better understanding of the roles of the teacher educators (mentors) that were present in the class during this intervention. Whereas many student teachers initially saw the teacher educators' role as judgemental and finding fault, later they realised that the teacher educators' role was of providing mentoring and support. The following remark by a student teacher serves as illustration (De Beer 2017):

> I was terrified by the presence of the Prof in class on the first day. Now I feel most comfortable, because I know he is going to provide supportive feedback that will help me to grow. (p. 22)

Another student commented (cited in De Beer 2017):

> 'At first I did not want to criticise my colleagues. However, I learned in this project that it is not being negative and finding fault, but that we as students should support each other, and provide other perspectives, so that we can all grow into super teachers. I did not only learn from the professors, but also from my student friends'. (Student teacher, undisclosed gender, date unknown)

□ The intervention facilitated the development of affective outcomes, such as taking responsibility for the learners and adopting a pedagogy of care

In the project, student teachers engaged with the learners on a weekly basis and came to know individual learners well. This is in contrast to the situation with school experience, where student teachers visit a school for a few weeks only and never come to know individual learners and their dispositions to learning. During

the intervention, the student teachers developed a sense of responsibility towards the learners. Student teachers experienced a feeling of pride and accomplishment, as can be seen from the following comment (De Beer 2017):

> 'By teaching these learners I feel such a sense of accomplishment. I felt that I was making a contribution that was worthwhile. I cannot wait to see them graduate'. Sizwe said, 'I'm praying that the students who are following us would treat our learners and present themselves the way we started it (as 2013 Life Sciences teachers)'. (p. 22)

One of the teacher educators reflected as follows:

> 'It was so satisfying to see how the student teachers developed real care and compassion for the learners they taught. They went out of their way to reflect on better pedagogies to use to ensure learner understanding, and I think they were more stressed than the learners themselves, during the examinations. They so much wanted their learners to excel'. (Student teacher, undisclosed gender, date unknown)

While analysing the data, we realised that there is a pattern in the acquisition of knowledge and skills reported on in all four of the above themes. In 'The findings illustrate student teacher learning across the zone of proximal teacher development' section, we further explore this.

The findings illustrate student teacher learning across the zone of proximal teacher development

After analysing our data and identifying the above themes, we read an article by Warford (2011) and realised that our findings are aligned with the process of development described in his work. We would therefore like to provide a more detailed account on the above four major themes, by following a more ontological approach. In the subsections that now follow, we show how student teachers typically progressed through the four stages identified by Warford (2011). We need to make it clear that we

conceptualised this intervention based on Vygotskyan principles but not intentionally according to the phases that Warford identified. It was only when we analysed our data, and we realised that the data clearly highlight this progression. Over the 2 years of this intervention, 81 student teachers were involved, and although each student teacher had a very individual trajectory of professional growth, the majority of the students showed the progression described by Warford's model in their professional growth. Some student teachers swiftly progressed to internalisation and recursion, and for other student teachers it took much longer. However, a general pattern could be seen in the data, indicating a general progression in students' views, and in their teaching, as the academic year progressed. Our argument is that the intervention successfully addressed the problems mentioned earlier of (1) the apprenticeship of observation, (2) enactment and (3) complexity.

Our view of student teacher professional development is underpinned by Vygotsky's ZPD (De Beer 2017:17; Vygotsky 1978). Warford (2011) has further developed this Vygotskian concept in relation to teacher development, and he coined the term 'ZPTD'. We find this a useful construct to reflect on the potential benefits of this intervention (De Beer 2017:17). According to Warford (2011:253), situated learning within a Vygotskian context makes provision for the border-crossing between the academic discourse of the university classroom and the experiential discourse of the school classroom (De Beer 2017:17). Warford stated that the ZPTD represents the distance between what 'student teachers can do on their own without assistance, and a proximal level they might attain through structured mediated assistance (scaffolding) from more capable others' (Warford 2011:253). In this case, the 'more capable others' are the teacher educators who serve as mentors to the student teachers, as well as peer mentoring by the student teachers themselves. Warford suggested a number of stages for this scaffolding within the ZPTD. We realised that our data and findings are well aligned with these four stages.

Stage 1: Student teachers are required to reflect on prior experiences and assumptions

At the beginning of the course and the intervention, we asked the student teachers to write reflective essays on their experiences and views of the teaching profession. In response, they also formulated rudimentary teaching philosophies. Many education students enter the teacher education programme with a very naïve understanding of what it means to be a teacher. Student teachers' learning is influenced by the 'baggage' of 12 years of schooling, and this is explained by Lortie's (1975) construct of the 'apprenticeship of observation' (which is discussed in detail in Ch. 7). This reflection exercise assisted teacher educators to develop an estimation of the actual level of development of the student teachers. In addition, the student teachers were required to write learning autobiographies, in which they reflected on their professional development on a weekly basis as the intervention progressed. Warford calls this the 'self-assistance stage'. Korthagen and Kessels (1999) showed that preconceptions about learning and teaching often do not agree with the theories taught in teacher education programmes and furthermore that these preconceptions have a remarkable resistance to change. We argue that the self-assistance stage, in which the student teachers reflected on their own views and beliefs (e.g. through the autobiography), cultivated a more conducive ZPTD, where student teachers were more open towards theoretical constructs that challenge them.

As we subscribe to the technique of prolepsis in this intervention, student teachers started teaching immediately at the beginning of the academic year. Whereas every lesson was planned in conjunction with the teacher educators, the first lesson was the exception, which provided the opportunity to determine how student teachers would teach without scaffolding or support. In Table 11.1, we summarise our findings.

The following excerpts from student teachers' reflections summarise the majority of the students' views on their first teaching experience (De Beer et al. 2013):

TABLE 11.1: Summary of findings during the initial phases of the programme (February and March, which in South Africa is the start of the academic year) (the different columns refer to the different data collection instruments that were used in the study).

Student teachers' autobiographies	Classroom observations/ student teaching (from RTOP instrument)	Student teachers reflections (after first lesson)	Interviews
Students reported to be anxious, excited, traumatised, shocked or glad for the opportunity. Very naïve teaching philosophies emerged, which did not take cognisance of the complexity of teaching in a systemic framework.	Transmission-mode teaching, mainly by making use of very poorly prepared PowerPoint slides, were common; very limited interaction with the learners; student teachers were nervous and lacked self-confidence; poorly prepared for the lessons; lack of adequate subject knowledge. Lack of sensitivity for student diversity and different needs.	Students used metaphors such as 'the sinking Titanic' or 'bungee jumping' – very scary, but at the same time exciting. However, the students' reflections were generally of poor quality, and not very critical. Many of the reflections indicated that the students were very pleased with poor transmission-mode lessons.	Student teachers confirmed the teacher educators' observations that the student teachers were not very critical in their reflections. Poor lessons were actually viewed as being of good quality, and if learners nodded during a PowerPoint-driven lesson, student teachers viewed it as an indication that the learners understood the work. In the initial phase of the intervention, many students viewed working in groups as stressful and indicated the desire to rather work individually.

Source: Authors' own creation, based on the stages in scaffolding across the ZPTD identified by Warford (2011). RTOP, reformed teaching observation protocol.

> Siphiwe: 'Overall and above this was an experience equivalent to 'bungee jumping' as everything gets heightened, this includes one's fear, anxiety, stress, emotions and the best thing one can do is to act calm and act a teacher, one who is in control and enjoy everything as it comes and learn from each learning experience.' (p. 572)
>
> Lebo: 'This first day felt to me like the sinking Titanic. I was SO nervous … and every time a learner asked a question, I could feel my heart racing in my chest … what if I cannot answer?' (p. 572)

Student teachers in general were not very critical in their reflections at the beginning. During his reflection on what we

considered a really bad lesson, one of the student teachers (cited in De Beer, Lautenbach & Batchelor 2013) stated that:

> '[*W*]hen I read the slides I saw them (the learners) nodding and acknowledging that they understand what I'm saying'. When asked what he felt did not work well, his answer was: 'What did not work for me is … no everything worked for me, nothing was wrong – a perfect lesson!' (Student teacher, undisclosed gender, date unknown) (p. 572)

Stage 2: The expert-other assistance stage

Warford refers to this stage as the expert-other assistance stage, implying that scaffolding or mediation will assist the student teacher in his or her professional development. As mentioned, we followed the Japanese Lesson Study model, and student teachers planned and presented lessons in small groups of four. The teacher educators involved critiqued the lesson plans, observed the lessons, provided critical yet supportive feedback on the lessons observed and also assisted the student teachers in planning practical work sessions in the laboratory, arranging of field trips and also setting tests and examination papers for the learners. We share the view of Van Lier (2004) that in an expanded ZPTD, scaffolding happens on four levels, namely, self-access, interaction with less capable peers, assistance from more capable peers and interaction with equal peers.

At first, student teachers viewed the teacher educators involved as being judgemental, but this slowly changed into the realisation that the teacher educators actually acted as mentors. Student teachers also started to value the peer support that stemmed from these small communities of practice. Table 11.2 summarises the findings during this phase.

Siphiwe wrote the following in his reflection, indicating that he valued teamwork with his colleagues and the peer mentoring (De Beer et al. 2013):

> Victory loves preparation, this is what I think me and my group represent, we planned in time and worked as a unit and delivered the lesson as smoothly and as enjoyable as possible. The planning process was quiet drastic as a lot had to go into it, including time

TABLE 11.2: Summary of findings during phase 2, the scaffolding within an expanded ZPTD (March to May).

Classroom observations/ student teaching	Student reflections	Student teacher interviews	Interviews with mentors (teacher educators)
Student teachers engaged the learners more during the lesson; asked more questions and took cognisance of the different levels in Bloom's taxonomy. Student teachers used more practical examples and gave more meaningful homework.	Reflections started to become more critical and nuanced. Whereas many student teachers were irritated by the 'lesson study' approach in the intervention, they started to reflect on the value of peer mentoring.	Student teachers reported on being more confident than in the beginning and also started to be more critical on their own practices.	There was a definite shift visible from the initial transmission-mode lecturing style, to more engaging practices, where learners participated. Student teachers were more at ease with each other.

Source: Authors' own creation, based on the stages in scaffolding across the ZPTD identified by Warford (2011).

> management which I think we executed perfectly as we started the lesson on time and finished in time, and also preparing for the practical in time before we went to class enabled us to execute the practical effectively enough for the leaner's to learn and have fun at the same time. (p. 573)

The 'fun' provides evidence that student teachers started to value a pedagogy of play, getting the learners to participate in learning activities as *Homo ludens,* the playing human.

Natalie again reflected on the role of the teacher educator providing guidance (cited in De Beer 2017):

> 'I was very nervous at the beginning, because this sporophyte and gametophyte and dominant generations are difficult concepts, but my lecturer explained it so nicely at the beginning of the lesson so I understood it better. This made me feel better and more confident. So I was nervous in the beginning but then I started to feel confident and I could enjoy it because these learners are stunning learners and ask good questions'. (Student teacher, undisclosed gender, date unknown)

Many of the student teachers reflected on the realisation that a teacher should be well prepared for a lesson and (especially with such bright learners) expect that they will ask difficult questions (cited in De Beer 2017):

> 'I really enjoyed the learners and the questions that they asked. Absolutely brilliant even though we did look like monkeys most of the time if we could not answer their questions, but in a normal school environment if a kid asks you a question that you don't know … it doesn't really happen, so I think it's stuff for us to think of as well, because it's not always easy to think on your feet but if somebody would ask her a question maybe I would know, so we could help each other, so teamwork, I know it's not how it's going to be when I teach one day, but it's a nice way to work together.' (Student teacher, undisclosed gender, date unknown)

Thabo realised that teamwork is the key here and that his student colleagues could act as a safety net for him. Our observations showed that student teachers started to act as effective communities of practice, supporting each other where they could.

Stage 3: Internalisation

Student teachers were guided in their reflective practice, and reflection for practice, reflection in practice and reflection on practice were emphasised. After each cycle of lessons, student teachers individually reflected on their lessons, assisted by feedback from both their peers and the teacher educators. Student teachers started to develop an own footing and voice, as they engaged in critical reflection and journaling. Slowly the teacher educators started to witness more nuanced teaching philosophies. In this stage, there is often evidence that the student teacher starts to 'de-learn' some prior experiences or preconceptions, and start valuing new knowledge and practices. This we have indeed observed in this intervention.

Some student teachers started internalising their learning experiences early on in the programme, whereas other students only arrived at this stage towards the end of the academic year. In Table 11.3, a summary of the main findings is provided.

TABLE 11.3: Summary of findings during phase 3, the internalisation phase (April to November).

Classroom observations/ student teaching	Student teacher reflections	Student teacher interviews	Interviews with mentors (teacher educators)
Student teachers used narratives, case studies and more inquiry activities. Questions were asked on higher cognitive levels. Student teachers were much more sensitive towards individual learner needs. Better teamwork than before. Student teachers were more confident to support other students.	Student teachers were much more critically reflective and did not hesitate to critique bad pedagogy. They also came up with alternative approaches themselves.	In general, student teachers commented that they enjoyed the experience much more than the beginning of the year. They also started to value more creative teaching methods and inquiry-based laboratory lessons.	There was significant professional growth observable. Whereas some student teachers, in the beginning of the year, could not use a microscope, the student teachers were now able to plan and present very effective laboratory-based classes. Student teachers valued learner participation.

Source: Authors' own creation, based on the stages in scaffolding across the ZPTD identified by Warford (2011).

In this phase, we found evidence of internalisation of some of the concepts (e.g. more inquiry-based teaching) in the student teachers' practice, as well as far more nuanced reflections. To a question to Natalie on what she would, in hindsight, change if she had to teach the lesson again, she answered as such (cited in De Beer 2017):

> 'The introduction, I had a different idea and I wanted to use hydrophytes in an experiment on photosynthesis to show them the different adaptations, but I couldn't find any hydrophytes, so I had to change my introduction by using moss, it wasn't as amazing as the hydrophytes would have been'. (Student teacher, undisclosed gender, date unknown)

In a similar vein, Yvonne answered that, if she had to present her lesson again, she would (Cited in De Beer 2017):

> '[*E*]ngage the learners more than I did, ask them more questions while I'm teaching as supposed to them asking me questions all the time – that is still good because they are thinking for themselves, but that I pose questions that they start thinking about that. I think that

> would also solve the problem that they don't get so tired.' (Student teacher, undisclosed gender, date unknown)

Another student teacher reflected as follows:

> 'I'm very upset about the slideshow that wasn't very nice, maybe instead of the audio-visuals and video I wish we could've brought earthworms. I wanted to bring earthworms to take out but I had no time to go and buy them, which would have been nice if learners could've touched them. Or if I could've taken the tarantula Isabella out'. (The student teacher did have a tarantula, named Isabella, there, as an example of an arthropod, but we decided before the class that it is in the best interest of the learners and Isabella that the learners did not handle the spider). (Student teacher, undisclosed gender, date unknown)

The feelings of nervousness, and the metaphors of 'bungee jumping' and 'the sinking Titanic', gradually changed to more positive experiences:

> Danelle, during an interview after one of her lessons, said: 'It was very nice, it was something else, and these learners are here because they want to be here. I love it. These are very dedicated learners, they come here every Saturday because they do not have the subject at their school, I will teach here every Saturday, I really love it. I know they don't have a teacher so through my teaching I could have an influence in their learning and motivation in this subject'. (Student teacher, undisclosed gender, date unknown)

Stage 4: The recursion or the de-automatisation phase

This fourth stage described by Warford could be seen as the 'theory into practice' stage, as the student teachers confronted the dichotomy of theory and practice in all its intensity' (Warford 2011:255), implying that student teachers could use theoretical lenses to interrogate practice. Student teachers accommodated new concepts in their conceptual understanding, and this equilibration might entail discomfort and stress. Student teachers developed more nuanced teaching philosophies.

During this phase, we saw that many of the student teachers had mostly abandoned the transmission-mode of teaching that

TABLE 11.4: Summary of findings during phase 4, the recursion or de-automatisation phase (July–November).

Classroom observations/ student teaching	Student teacher reflections	Student teacher interviews	Interviews with mentors (teacher educators)
Learners effectively engaged in the lessons; many open-ended inquiries and practical work sessions were well facilitated. Student teachers were far less dependent on notes or PowerPoint slides and showed respect for learner diversity and became much more skilled in addressing learner needs.	Student teachers were critically reflective; they knew their own strengths and shortcomings better. They were better able to identify gaps in their traditional school experience and had an insight into how this intervention provided opportunities that did not always manifest during school practicum. More nuanced teaching philosophies were displayed, drawing on theorists such as Piaget, Vygotsky, Gardner, etc.	They celebrated their professional growth and saw the value of this intervention. Student teachers showed a pedagogy of care and expressed their concerns about the next group of student teachers, who would be taking over the following year.	There was a definite shift in emphasis towards more inquiry-based approaches. Student teachers showed a remarkable growth in terms of pedagogical content knowledge. Hopefully, new pedagogies were well established and will not be 'washed out'.

Source: Authors' own creation, based on the stages in scaffolding across the ZPTD identified by Warford (2011).

characterised their initial lessons. Whereas student teachers initially showed resistance towards incorporating more inquiry-based approaches, they became far more confident and skilled in planning practical work sessions that were more towards the open-ended inquiry spectrum. We saw far less 'cookbook' laboratory activities. Student teachers also showed a far more nuanced understandings of the complexity of the teaching profession. In Table 11.4, we summarise the findings.

One of the teacher educators commented (cited in De Beer 2017):

> 'Wow, what a wonderful example of inquiry learning. Learners had to formulate a hypothesis and plan an investigation. The decibel level in the lab testifies to the enjoyment of the activity by the learners'. (Student teacher, undisclosed gender, date unknown)

Yvonne had the following to say (cited in De Beer 2017), when she was asked during the interview what value she personally gained through her involvement in this intervention:

> 'There are two aspects – individually – for me this is a great opportunity to gain experience in teaching the subject that I will be teaching someday … I get an opportunity to practice the type of questions to ask while you are teaching, and to reflect on your lesson … so that I don't make the same mistakes when I'm a practising teacher. For the learners, I think that it is good that they have currently studying students teaching them, so it's not old ways of teaching that they are getting, its ways that we got taught in our classes … so it's a new generation way of teaching'. (Student teacher, undisclosed gender, date unknown)

Yvonne's first lesson was, like most of the student teachers' lessons at the beginning of the year, transmission-mode lecturing. However, as the intervention unfolded, she started to plan more engaging activities for the learners, and eventually also more open-ended inquiry lessons.

Student teachers compared this experience to their usual teaching experience in other schools (that they still do). One of the student teachers commented (cited in De Beer 2017):

> 'I really think that having kids that are so smart is a big benefit to us because not a lot of us will be teaching at a private school where you have these type of learners; normal kids are very average and they normally don't prepare before class, they don't study before class. They come to class and they don't know anything, so they can't ask all these nice questions. It helps a lot'. (Student teacher, undisclosed gender, date unknown)

Another student teacher added to this sentiment:

> 'In many schools, we can get away with little planning. One often spends half the period disciplining the kids. This intervention made me realise that a teacher should be well prepared, and should engage the learners'. (Student teacher, undisclosed gender, date unknown)

Another student teacher reflected as follows (cited in De Beer 2017):

> 'I worked in a location (poor socio-economic areas, with often informal housing) school and I was a learner in a former model C school so I've

> been exposed to learners in the location schools .... they do not get exposed to the resources as the learners here are exposed to. The apparatus in their classrooms are not on the same standard as the apparatus here; here things were created for the learners so that they can understand the stuff. When you go to schools you have to finish with the syllabus, and getting the learners to understand the content, it's all about rushing to finish the syllabus'. (Student teacher, undisclosed gender, date unknown)

Student teachers also commented towards the end of the year on their personal growth, and the development of self-confidence (cited in De Beer 2017):

> 'I want to comment on my personal development; as an education student I always imagined my worst case scenario to be discipline and I also imagined very smart learners asking me questions that I couldn't answer. But I was with these children today and I saw that, OK, I could handle smart children, then my worst case scenario just became my best case scenario. Now I don't think there is any stumbling block that I cannot overcome when I go back to my school, I have this self-confidence that when I go back to my average learners and they try to act smart with me, I know that I was dealing with smarter children'. (Student teacher, undisclosed gender, date unknown)

Student teachers also came to realise the complexity of teaching, as can be seen in Memory's reflection (cited in De Beer 2017):

> '[*T*]eaching is complicated and not simple, you need to conquer your fear. Don't give up. You can plan but it can flop but you need to think on your feet. Courage doesn't mean to have no fear, you are going to make mistakes, but you can learn from it and improve'. (Student teacher, undisclosed gender, date unknown)

It is interesting to note how student teachers' metaphors have changed over the period of a year. Metaphors such as that of the 'sinking Titanic' were replaced by metaphors such as the following (cited in De Beer 2017):

> 'I am the eagle – I can fly! This project has given me wings – I feel confident to go and teach next year.' (p. 25)

> 'I feel like a concerned parent. Will next year's group of students care as much for these learners, as we did?' (Student teacher, undisclosed gender, date unknown)

Comparing the student teachers who participated in this intervention to their peers who did not

One could of course ask the question whether such progression would not also be seen amongst student teachers who were only subjected to the more conventional school practicum model. We would think that one would see the same progression, but we argue here that there are nuanced differences – for example, this intervention centre-staged inquiry learning. Owing to the large number of student teachers in this course (*n* = 140 in 2014), only a limited number of student teachers (*n* = 55) could be accommodated in the intervention in 2014. It must be pointed out that these 55 students also taught in other schools during the school practice period. Students who did not participate in the intervention had to visit schools for 7 weeks, while the students who participated in the intervention only went to other schools for 5 weeks – they obtained 2 weeks' credit for their involvement in this intervention. The other student teachers (*n* = 85) engaged in traditional school practice, for a period of 7 weeks. All 140 student teachers had to present three lessons for assessment purposes: two of the lessons were assessed by teachers in the respective schools, and one of the lessons by a teacher educator. It was interesting to note how, in general, the student teachers who were involved in the intervention did better in their assessments, compared to the student teachers who were not involved in the intervention. (This is communicated in another publication.) The average mark (based on three assessments for each student) of the student teachers who were involved in this intervention was 80.49%, compared to an average mark of 69.78% for the students who were not involved in this intervention. Based on the fact that the experimental group on average obtained a mark which was 10.71% better than the control group, we argue that such an intervention enhances student teachers' development across the ZPTD.

Implications of the findings and conclusion

Firstly, we need to highlight that this is an intervention that is not easy to replicate. We capitalised on a situation where a good school, in close proximity to the university, was willing to accommodate the intervention, and the university saw the potential of such an intervention in terms of the professional development of its student teachers. However, the results clearly showed that some of the limitations of traditional school experience were effectively addressed.

This intervention showed that involving student teachers in challenging, authentic teaching situations, and 'throwing them in at the deep end' (prolepsis), holds affordances for their professional development as future teachers (De Beer et al. 2013; De Beer 2017). However, it is a requirement that there should be sufficient scaffolding and support. These life sciences student teachers had to take responsibility for the learners. An important outcome achieved was that these student teachers came to realise the affordances of inquiry learning approaches and laboratory work, which emphasises the tenets of science in life sciences (De Beer et al. 2013; De Beer 2017). Over the course of the year, the teacher educators saw student teachers replacing transmission-mode PowerPoint-slide-driven lessons with problem-based, open-ended inquiry lessons (De Beer 2017). In order to reflect the true nature of the natural sciences in the classroom, it is essential for student teachers to get hands-on experiences of inquiry labs, and how to structure it. This intervention provided such experiences to student teachers. For example, at least two of the student teachers did not know how to do microscopy at the beginning of the intervention (De Beer 2017). A fourth-year student, who has been to schools on several occasions (school practice), had *never* witnessed a lab/practical work session. Whereas student teachers often report that school experience does not assist them in acquiring these skills, this intervention assisted them in developing such skills and insights. Towards the end of the academic year, student teachers

provided evidence of creative problem-based lessons, reflecting the true nature (tenets) of science (De Beer et al. 2013).

Another factor that enhanced the learning of student teachers was that the learners involved in this intervention (intelligent, motivated and keen to learn) challenged student teachers all the time, and this enhanced student teachers' own PCK development (De Beer et al. 2013). The teacher educators reported a significant growth in student teachers' understanding of the Shulman concept of PCK. Several student teachers indicated that the traditional school experience was helpful in sharpening their classroom management and discipline skills, but that they 'could get away' with being unprepared for lessons or having insufficient knowledge (De Beer 2017; De Beer et al. 2013). Their involvement in this project however highlighted the importance of having sound subject and pedagogical knowledge. Student teachers reported on how this realisation enhanced their SDL (De Beer 2017).

The role of student mentors was taken up by the teacher educators involved in the life sciences intervention. This experience alerted them to the time-consuming nature of such mentorship (if it is done well). The teacher educators also reported on how pleased they were with the Japanese lesson study model that was used in the project. Although many of the student teachers did not like the CL environment created by the lesson study model (and would rather work on their own), it is essential that they were introduced to the affordances of a community of practice.

Such an intervention programme should be structured such that student teachers assume *responsibility* for the learners (De Beer et al. 2013). The data showed that the student teachers did take up such responsibility, and they felt like *real* teachers who had to demonstrate a pedagogy of care. We are of the opinion that the intervention assisted the student teachers in their development of teacher identity, namely, to start acting like teachers, and not simply thinking like teachers (De Beer et al. 2013; De Beer 2017).

Prolepsis provides student teachers with the necessary support, within an enhanced learning trajectory, within the

Vygotskyan ZPTD (De Beer 2017). This research shows that scaffolding by the teacher educators (as mentors), less capable peers, more capable peers and equal peers, contribute to learning within an expanded ZPD (De Beer 2017). The data also show that student teachers learnt the value of collegiality and to appreciate the value of working within a community of practice.

Zeichner and Tabachnick (1981) warned that, very often, concepts taught during teacher education are 'washed out' during practical experiences. It seems though as if student teachers saw the practical value of what they have learnt, especially the affordances of engaging pedagogies, during this intervention (De Beer 2017). Hopefully, this would prevent the 'washing out' effect when they start teaching in other schools (De Beer et al. 2013; De Beer 2017).

This intervention successfully addressed three fundamental problems associated with learning to teach, namely, the apprenticeship of observation, the problem of enactment and complexity (De Beer 2017). It is clear that the intervention scaffolded the learning and professional development of student teachers so that they not only thought like teachers but also acted like teachers. The intervention further developed more nuanced understandings of the complexity of the teaching profession amongst student teachers (De Beer et al. 2013).

As noted before – this intervention is not easily replicated. However, we are of the view that the learning elicited could be used to inform traditional school experience practices.

To conclude, we concur with De Beer (2017), who stated that teacher educators often criticise the school experience component of pre-service teacher education, yet they do not consider ways in which such shortcomings could be addressed in their methodology courses. De Beer suggests that teacher educators should, through a scholarship of teaching and learning, create 'low-risk settings' (Schön 1987) for novice learning, to address the so-called theory–practice divide.