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# Learning to teach Biology to pre-service teachers: A self-study

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Hlologelo Climant Khoza

A thesis submitted to the Wits School of Education, Faculty of Humanities, University of the Witwatersrand in fulfilment of the requirements for the degree of Doctor of Philosophy

04 September 2020

# Abstract

Due to the lack of formal training for those who wish to be teacher educators in South Africa and around the world, I did on-the-job training and used a self-study methodology to explore how I, as a novice teacher educator, can learn to teach biology to pre-service teachers. I viewed learning as the "coming-to know" process facilitated by constructive interactions and observations in a community of practice. I was the main participant. The other participants were my 135 pre-service teachers whom I was teaching in the course and six biology teacher educators who were working in the same department. I collected data through journaling, observations of and discussions with the experienced biology teacher educators, audio- and video-recordings of my lectures, discussions with critical friends and interviews with students. Narrative text analysis was used to draw insights. The student interviews and discussions with experienced teacher educators were analysed using both inductive and deductive approaches. This study showed that one can learn to teach pre-service teachers in systematic ways and approaches. These systematic ways include reflecting on experiences accumulated over the years, observing experienced teacher educators as they teach and discussing with them, teaching a topic for a short period with the help of the experienced teacher educators, moving from general observations and discussions to focusing on particular aspects of practice and planning and teaching a full module. In this thesis, I demonstrate how these approaches helped me learn and the knowledge and skills I gained in the process. The findings in this study showed that a novice teacher educator can learn about teaching practice by engaging in critical reflection based on their students' feedback. I further demonstrate that, for this reflection and learning to be meaningful, the feedback has to be sought continuously from the students being taught. Using the findings from this study, I proposed a model or framework for learning that novice teacher educators can adopt not only to acquire practices of teaching biology to pre-service teachers but also to track their learning. Recommendations for future research are also highlighted.



**Key words**

Teacher education; learning; biology; pre-service teachers; self-study; reflection; narratives, pedagogical content knowledge; professional judgement

# Declaration

I declare that this thesis is my own, unaided work. It is being submitted for the Degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg, South Africa. It has not been submitted before for any degree or examination in any other University.



Hlologelo Climant Khoza

Date: 04 September 2020

# Dedication

To my late grandmother, Raesibe. You have raised me. May your soul rest in eternal peace Pheladi!

To my mother; Ramolokoane. I am here because of your endurance!

To my sibling Mahlomola and my son Tsibisho. All this is to inspire you!

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- My cousin Mmatlala who supported me when I stayed late on campus.
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The National Research Foundation (NRF) for granting me the scholarship to study for this degree.

The One who is above everything. The God who has been with me from my infancy until now. He has granted me the gift of life and strength to complete this PhD.

## Presentations and publications emanating from this study

Khoza, H.C., Msimanga, A. & Nyamupangedengu, E. (2020). In search of the fundamentals of planning that can foster the delight of teaching and learning biology in pre-service teacher education classrooms. In P. Vale & L. Westaway (Eds.). *Proceedings of the 28th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education* (pp. 236-245). Eastern Cape, South Africa: SAARMSTE. **[Incorporated in Chapter 6]**

Khoza H.C., Msimanga, A., & Nyamupangedengu, E. (2019). Reflecting on the preparation of PowerPoint slides as a resource in biology lectures. In M. Good & C. Stevenson-Mill (Eds.). *Proceedings of the 27th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education* (pp. 511-515). Kwa-Zulu Natal, South Africa: SAARMSTE. **[Incorporated in Chapters 4 and 6]**

Khoza, H. C., & Nyamupangedengu, E. (2018). Prompts used by biology lecturers in large lecture group settings to promote student interaction. *African Journal of Research in Mathematics, Science and Technology Education*, *22*(3), 386-395. **[Incorporated in Chapter 5]**

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# List of acronyms and abbreviations

**B.Ed.** – Bachelor of Education

**PhD** – Doctor of Philosophy

**LS** – Life Sciences

**PS** – Physical Sciences

**NS** – Natural Sciences

**CoP** – Community of Practice

**HEI** – Higher Education Institution

**PCK** – Pedagogical Content Knowledge

**Wits** – University of the Witwatersrand

**CAPS** – Curriculum and Assessment Policy Statement

**IEB** – Independent Examination Board

**CoRe** – Content Representation

# CHAPTER 1: INTRODUCTION AND BACKGROUND TO THE STUDY

## 1.1 INTRODUCTION

Knowledge about teaching is and can be acquired in many ways. For example, teachers acquire the knowledge of teaching through training (attending lectures and doing teaching practicals) and obtain a teaching qualification (Naylor, Campbell-Evans & Maloney, 2015). However, how those who teach teachers – teacher educators[1] – acquire the knowledge of teaching is not yet clear in the literature (Hollins, Luna & Lopez, 2014; Loughran & Menter, 2019) especially teacher educators who teach science subjects (Abell, Rogers, Hanuscin, Lee & Gagnon, 2009).

A common path to becoming a teacher educator is through school teaching whereby teachers teach in schools for several years, and then through pursuing a Master's and/or doctoral studies, the school teacher ultimately becomes a teacher educator (Dinkelman, Margolis & Sikkenga, 2006; McDonough, 2017). This suggests that being a teacher educator is not a career that one plans for entering into (Berry & Van Driel, 2012; Montenegro Maggio, 2016). It is assumed that if an individual has some school experience, they will be able to cope with teaching pre-service teachers[2] at the university level. This does not seem to be the case as Conrad and Four-Babb (2013), and Dinkelman et al. (2006) indicate that individuals who move to the field of teacher education from being school teachers have difficulty in adapting. One needs to understand that school teaching and university teaching are different. In many teacher education institutions, teacher educators teach about teaching to people who will be teachers or as is the case in my institution; they teach content and how to teach it. So, not only the content is taught but also the ways of teaching that content (see Section 1.7 of this chapter). The idea of teaching both the content and the methodology explains why new teacher educators face challenges when teaching pre-service teachers regardless of their previous teaching experiences even though these experiences can also be used in the process of learning through critical reflection (Goodell, 2006).

[1] Teacher educators are generally defined as the people who train pre-service teachers and sometimes professionally develop in-service teachers (Klecka, Donovan, Venditti & Short, 2008)
[2] Pre-service teachers are students who are studying to become teachers.

There is a lot that is missing from literature about how teacher educators learn to teach pre-service science teachers and develop their knowledge base (Demirdöğen, Aydin & Tarkin, 2015). The question of how one gains the practical knowledge of teaching pre-service teachers is still not answered. This PhD study was conducted to contribute to this gap. I engaged in a self-study to investigate how I learn about or gain knowledge of teaching a biology content course to pre-service teachers. The motivation for this study is presented in Section 1.4 of this chapter. Below I position myself in the study by describing how I got to my PhD. This description also sets the scene for the presentation of my experiences and reflections in Section 1.3 of this chapter.

## 1.2 WHO AM I?

I am a qualified Biology[3] teacher with a Bachelor of Education (B.Ed.) degree from the University of the Witwatersrand. Immediately after my undergraduate degree, I enrolled for my Honours degree then a master's degree at the same university. Concurrent with my studies, I was working as a high school Life Sciences (LS) teacher. In the duration of my postgraduate studies, I was also involved as a demonstrator[4] in science laboratories. I taught for two and a half years. I then registered for a PhD degree to become a lecturer. What was not settling well with me was that to obtain a PhD degree, you have to do research, and the research prepares one to be a researcher but not necessarily to teach pre-service teachers. This meant that at the end of my PhD, I would still be prepared to teach learners at high school level as a result of my B.Ed. training and not pre-service teachers. This became the motivation for undertaking this PhD self-study. Below I describe my story of how I got to this point from being a school learner to the commencement of my PhD. I present these experiences because they greatly influenced my practice. It is indicated in the self-study literature that when we reflect on our experiences, we use them as springboards to reflect and make decisions about the current and future (Kleinsasser, 2000; LaBoskey, 2004).

[3] In South Africa, Biology as a subject is called LS. I will use the terms Biology and LS synonymously throughout the thesis

[4] Literature uses the term tutors. In the WSoE, demonstrators are responsible to run practical activities in the labs and tutorials. Most of them are postgraduate students studying full-time. I will use the term demonstrator synonymously with tutor.

## 1.3 MY EXPERIENCES AS A SCHOOL LEARNER AND THE ROAD TO MY PHD

As argued by Akinbode (2013), a lot of what we do as teachers is shaped by who we are and how we use our personal and professional lived experiences to understand our practice in context. In addition, Pinnegar and Hamilton (2009) state that self-study is shaped by one's histories and what one encountered in the past. Successful self-study practitioners use their reflections on these experiences to inform their practice and their current thinking (McDonough, 2017; Samaras, Hicks & Berger, 2004). This means, our past experiences, thoughts, and actions cannot be avoided in self-study. In this section of the chapter, I present my autobiography from being a school learner to the commencement of my PhD. This autobiography was presented to my supervisors and critical friends (see Section 3.7 of Chapter 3 for an explanation of what critical friends are and their role in self-study). As I was reflecting on my autobiography, I incorporated their comments and questions.

### 1.3.1 My journey and experiences as a school learner

I started primary schooling when I was still six years old (1998) at a school called Ditlhakaneng situated in Makgophong Village, Zebediela, Limpopo Province. From an early age, I wanted to become a teacher, probably because this was one of the few professions I was exposed to when growing up. From as early as Grade 5, I started imitating my teachers in the classrooms and at home. I would make a board from used old corrugated iron sheets at the back of the house and use charcoal as chalk to write. I would teach my young cousins by imitating certain teachers in our school. I imitated specific teachers that taught well, and I could understand what they were teaching. At times, my friends who stayed in the neighbourhood would join me, and as time went by, they started calling me "Meneer"[5]. My quest for becoming a teacher grew as I went up to the senior primary. From Grade 6 to high school, the Meneer title started to spread around the school. The teachers then noticed this and used it to their advantage and perhaps also to my advantage. For example, they would give me notes to go and write on the board for other learners to copy, and they would ask me to help them with marking. Throughout high school, I was still interested in becoming a teacher and in my last two years (Grade 11 and 12). When we would have afternoon

[5] Meneer is an Afrikaans word for Sir when used alone. In South Africa, it is a norm to call all male teachers Sir. In some schools (especially rural areas), the term meneer is used.

classes, I would volunteer to lead revision discussions where I ended up teaching because I enjoyed it. At this point, how I taught my fellow learners was influenced by specific teachers. Eunice asked if I would consider marking my peers' books a good practice while Nelly asked about the teachers I imitated and why I imitated those teachers.

**My reflection:** Now that I am a qualified teacher, I would not consider marking other learners' work as a learner a good practice. A teacher has to mark learners' books and give them feedback. The other learners were denied the opportunity to get this feedback from the teachers. It would have been beneficial for us as learners to engage in peer-assessment for everyone to learn (Topping, 2009). However, copying notes for other learners on the board helped me to learn how to write on the board and I used this experience in my teaching and also now as a novice teacher educator. Marking other learners' activities allowed me to have a sense of how they thought. This elevated my desire to become a teacher.

I imitated teachers based on what I liked about them and what I found interesting about them. For example, I would imitate one teacher because I liked the way they disciplined learners, and I would imitate the other for their handwriting on the board and how they used the board when teaching. Some teachers were just "boring"[6] to me. Since I was involved, either directly or indirectly, in the process of teaching and learning through writing notes on the board for learners, marking learners' classwork books and tests and taught some of my peers, the experiences remained in my memories. Now, as I reflect on these experiences, I find myself questioning how some of my high school teachers taught and why they taught in that manner. I would give an example of my LS teacher. I was not happy with how LS was taught because the teacher was always reading from the textbook. Most learners in the school, however, regarded him as a good teacher because he was very firm and his class was always quiet. He always copied the subject content from the textbook and asked us to take down notes from the board without engaging us in discussions. This did not help me in any way because we all had the textbook that we could read from. Even though it was a different textbook, the content was identical. Since I now have formal knowledge of what teaching is all about and some understanding of what constitutes good teaching, I would say the teacher did not have the ***pedagogical knowledge*** and lacked skills to ***transform the content knowledge*** for us to

[6] I am using the word 'boring' to signify that I did not enjoy the way those teachers were teaching. There was something lacking but I could not pinpoint what was lacking in the way they did things.

understand (Mavhunga, 2018; Shulman, 1987). What was then left for me to do at that point was to adopt rote learning to pass and continue with my studies. Now, as a trained high school teacher, I understand the implications of being unable to transform the content knowledge in ways that my students will understand – My students will resort to rote learning to pass the course.

### 1.3.2 My experiences post-secondary school as a pre-service teacher

In 2010, my career became real. I registered as a first-year student for the B.Ed. programme at the University of the Witwatersrand and chose Mathematics as my major subject. In my second year of study, we had to choose a sub-major subject and I chose LS (see Table 1.1 for the structure of the B.Ed. programme). Below, I present some of the encounters and my experiences from 2010 as a first-year student to the commencement of my PhD. The aim of presenting these details here is to show how they influenced my thinking about some of my practices as a novice teacher educator. I articulate some of these experiences in Chapter 4.

***Experience 1:*** My third year Teaching Experience as a student teacher

As part of the requirements in the institution, we had to do teaching experience (TE)[7] for three weeks per semester. We were allocated university mentors who had to come to our schools and assess our teaching at least twice for each TE depending on the year of study. In my second TE of my third year of studies (the year 2012), I was placed at a public school in a township situated in Johannesburg[8]. I was allocated Grade 9 Natural Sciences (NS) and Grade 10 LS. My university mentor wrote in the assessment report that I have a good understanding of the content knowledge but lack better ways of presenting that content to the learners. These comments were based on how I had taught the human circulatory system to the grade 10 class.

During the feedback session after my lesson, one of the suggestions that I got from my university mentor was that I needed to always find out from the internet how to teach specific topics. Although I found this tip to be useful and relevant, it was also surprising for me because it made me question the significance of attending lectures in the institution if I still cannot teach better. This became a critical experience because reflecting on it made me question myself: "what is the

[7] This is when pre-service teachers go to schools and teach under supervision of mentors. Literature uses the term teaching practice.

[8] In South Africa, there are public schools that are owned and governed by the government; hence they receive a 100% subsidy. A township means a place of predominantly blacks with similar socio-economic status.

role of a teacher educator in class if I always have to go to the internet and find out how biology topics are taught?" Although searching for information on the internet can be one of the approaches to finding out how best to teach the topic, how then do I use internet materials whenever I get them?

**My reflection:** Although my university mentor's feedback was surprising at the time I was a student in the sense that I could not understand what she meant, reflecting on this experience helped me to realise certain aspects of teaching pre-service teachers. My university mentor's comment meant that there are better ways of presenting content in particular contexts and the internet can be a good resource to access ways of teaching biology topics. She wanted to make me aware of the complexity of applying what they taught to us in our lectures. The role of lectures is to help students gather information that can be of use to teach in schools. It does not necessarily mean that the teacher educators had to give us all the approaches and strategies of teaching. From this experience, I learnt that as a teacher educator I needed to help my students understand that what I am teaching them in the lectures forms a foundation of what they will use to teach in their schools. However, they still need to find ways of teaching based on their contexts.

***Experience 2:*** Being taught LS by a "different" teacher educator

In my third year of study, we did NS[9] (chemistry, LS, astronomy, and physics). Having planned my career that I wanted to be a mathematics and physical sciences (PS)[10] teacher, we had to either choose PS or LS in our fourth year. My decision of taking PS changed in my third year because of my experiences of teacher educators who taught PS parts of the NS I and II (see Table 1.2). I did not do well in PS because I did not understand the teacher educator – I did not understand the way he was teaching. Furthermore, he did not have time for questions during classes. I did not choose PS because of how it was taught to me in my second and third years of study. In contrast, the LS teacher educator was more like a teacher in the sense that she used a variety of teaching approaches to help us understand the content as opposed to direct transmission of information. For example,

[9]NS is a subject offered from Grade 6 to 9 (senior phase) and encompasses the content of physics, chemistry, LS and astronomy.

[10] In South Africa, physical science is taught as a combination of chemistry and physics from Grade 10 to Grade 12. Even in the National Senior Certificate examination (NSC), learners write an intense physics paper (paper 1) and chemistry paper (paper 2).

the teacher educator used an analogy to a person's address to explain the taxonomy of animals. I went into my fourth year with a drive and passion for becoming a good LS teacher.

**My reflection:** I have realised that I enjoyed and learnt more from my LS lecturer because she showed us what teaching was all about and specifically teaching science to learners. I can still remember some of the content and what we did in that module. In other words, she was modelling practice to us as pre-service teachers. These experiences became part of the influencers of my pedagogical thoughts and practices because reflecting on the pedagogical approaches that the teacher educator used made me think of what it means to teach a content course to pre-service teachers.

***Experience 3:*** Being a high school teacher for two and a half years

In 2014, concurrent with my postgraduate studies, I got a part-time job as high school mathematics and NS teacher at an independent school[11]. I taught mathematics to grades 8 and 9 and NS to Grade 8. I found that I enjoyed teaching NS more than mathematics because of its nature – that most of the content explained the natural phenomena to which we all had access. Since I was a qualified LS teacher, I was given Grade 10 and 11 classes to teach but still had the grade 9 NS class in 2015.

I was also asked to manage twelve (12) student-teacher interns who were doing their B. Ed qualification through distance learning. Out of the 12 student teachers, four (4) were studying to become LS teachers. My role was to mentor them, visit their classrooms and evaluate their teaching. Just like myself during TE in my third year of undergraduate studies, my observations of the four LS student teachers revealed that they were transmitting the isolated facts and concepts of a particular topic. In our discussions, one of the factors that contributed to their practice was how they were taught and that they did not have access to a good model of an LS teacher. They relied on what they had observed from their mentor teachers and the fact that they did not attend lectures to learn about how to teach specific biology topics disadvantaged them.

**My reflection:** I have indicated that I have now realised the significance of lectures from a different perspective. Although I had not been trained to mentor the student teachers or given any guidelines, my experience of mentoring them helped me realise that what teacher educators do in

[11] Unlike public schools as described, independent schools do not receive 100% subsidy from the government. They rely on children's fees and other sources.

lectures makes a difference to the pre-service teachers' practices of teaching in schools. To me, this signified how advantageous it is for the pre-service teachers to attend lectures and learn the subject content and to some extent, the content about teaching the subject. For pre-service teachers to appreciate the advantage of attending lectures, teacher educators need to strive to make their learning meaningful and worthwhile both in terms of the content knowledge and the pedagogy. These observations have motivated me to aspire to teach my biology pre-service teachers the content knowledge and be a good model of a biology teacher.

I have presented my experiences and reflections from being a school learner and my experiences post-secondary school as a pre-service teacher then a school teacher. In these experiences, I pulled some of the specific events that contributed to my practice of learning to teach biology. The experiences motivated me to become a biology teacher educator. My desire was to contribute to the preparation of biology teachers. In the next section, I use literature to present the motivation for this PhD.

## 1.4 MOTIVATION FOR THIS STUDY

Unlike teachers who formally study and attain a qualification to go and teach in schools, teacher educators do not have that kind of training (Dinkelman et al., 2006). I have indicated in the introduction to this chapter that a lot of new teacher educators enter the teacher education programme with some experience of being school teachers but with limited experience in teacher education. It is because of this realisation that most institutions have introduced induction programmes for new teacher educators to equip them with the required skills and competencies for teaching pre-service teachers (Murray & Harrison, 2008). For van Velzen, van der Klink, Swennen and Yaffe (2010), this would be a second induction as these teacher educators would have been inducted into their roles of being school teachers before becoming teacher educators. Even though countries such as England and Israel have introduced induction programmes to support new teacher educators (Murray, 2008; van Velzen et al., 2010), the results have not been satisfactory as the programmes have been inconsistent and were continuously changing (Reichenberg, Avissar & Sagee, 2015). This is a cause for concern as van Velzen et al. (2010) found out that these induction programs are not satisfying for the critical work that teacher educators need to do – the work of teaching pre-service teachers.

According to van Velzen et al. (2010), the induction of teacher educators is a two-fold programme in a sense that it focuses on the teacher educators' understanding of the administrative aspects of the institution and also their professional duties (e.g. teaching and research) at the same time; leading to the ineffectiveness of these inductions. The above is true for the South African context where there are no uniform guidelines that can be used to induct new lecturers into their roles leading to inductions happening at an institutional or departmental level (Hlengwa, 2019; Osman & Hornsby, 2016; Teferra, 2016). The inductions are not primarily focused on the scholarship of teaching and developing teacher educators' knowledge base for teaching the pre-service teachers. Despite different roles that teacher educators need to fulfil, the scholarship of research is more emphasised (Abell et al., 2009). Yet, teaching is one of the key roles of a teacher educator (Korthagen, Loughran & Lunenberg, 2005; Murray, 2008). There is, therefore, a gap in knowledge of what teacher educators do and how they construct and perceive their teaching (Goodwin & Kosnik, 2013). Systematic research on and/or by *new* teacher educators and how they construct their practice of teaching pre-service teachers is needed to address the limited knowledge of what it means to be a teacher educator (Berry & Van Driel, 2012). This includes how the new teacher educators can access the knowledge of teaching pre-service teachers.

The reflections on my experiences as presented in the previous section and the literature above brings about two key themes which undergird my motivation for doing this study:

1. *Lack of formal training for new teacher educators* – the only available information with regards to who can be a teacher educator is focused on academic qualifications. That is, to be a teacher educator, a master's or PhD degree would be required (depending on the institutional and national policies). Universities do not have formal training or guided induction for new teacher educators on how to teach pre-service teachers. The assumption is that some experience of school teaching will help the new teacher educators "survive" in the teacher education context. However, my experience and literature tell me that new teacher educators face numerous challenges when teaching pre-service teachers regardless of their school teaching experience.
2. *Less emphasis on teaching in the science education doctoral programs* – Many doctoral programmes in science education do not emphasise teaching to the doctoral candidates. A lot of focus is on research and completion of the PhD, yet if the candidate plans to go into

academia, one of the key roles is teaching the pre-service teachers. Moreover, the integral part of being a lecturer is teaching.

The two key themes above summarise the motivation for this study. Lack of formal training for new teacher educators in South Africa and around the world and less emphasis on teaching in the doctoral programmes leave new teacher educators with challenges. The new teacher educators do not have opportunities to learn to teach pre-service teachers and acquiring the knowledge and skills of teaching. The current study is, therefore, aimed at contributing to this body of work and move it forward in specific ways both in terms of how new teacher educators can learn and the practices and pedagogies needed to teach content to pre-service teachers.

## 1.5 THE PURPOSE OF MY STUDY

While the previous section briefly outlined the motivation for this study, this section is focused on the purpose of this study. Teachers can look at their own practice and understand and understand it through a self-study (Berry, 2008). Teacher educators can research their apprenticeship into a new role of teaching by using a self-study methodology, and this is vitally important due to the lack of formal training for new teacher educators. This is because self-study offers unique ways of engaging with experiences, thoughts, and actions through reflection. Loughran (2007) asserts that self-study improves one's practice and creates ways of better understanding one's professional knowledge. Teacher educators need to be conscious of their roles and responsibilities due to the influence that they are likely to have on teachers' competences and professional development (Goodwin & Kosnik, 2013).

I believe that I can gain knowledge of teaching science to pre-service teachers from studying teacher educators who are already practising. I have adopted the self-study methodology in this study for two main reasons. Firstly, because of the benefits and implications of using this methodology, especially the fact that the findings have a direct impact on the researched individual. Secondly, research shows that most teacher educators (who did not undergo training for teaching pre-service teachers) are themselves under-researched (Korthagen et al., 2005; Murray, 2008) posing challenges in accessing the tacit knowledge. New teacher educator needs to learn from the experiences of his teachers while his or her practice is the focus of research. Therefore, the main purpose of this study was to investigate how, as a new science teacher educator, I learn to teach a

biology content course to pre-service teachers using a self-study methodology to reveal the knowledge, skills, and competencies required to teach. It is important to note that I did on-the-job training as I was learning to teach by teaching the pre-service teachers.

## 1.6 MY RESEARCH QUESTIONS

This section outlines the research questions that guided this study. Research questions are important for every academic research because they guide the researcher in executing the study (McMillan & Schumacher, 2010). Research questions dictate the design and methodology of the study. Research questions need to be feasible such that their answers can contribute to the available body of knowledge. Samaras (2011) argues that research that uses self-study methodology is guided by research questions about the "self" aimed at improving practice. This means the research questions are expressed using the first person pronoun. The main research question for this study was: ***How do I learn to teach biology to pre-service teachers?*** This research question had four sub-questions:

1. What do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?
2. How do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?
3. How does planning and teaching a biology topic help me learn to teach biology to pre-service teachers?
4. What knowledge about my teaching do I gain from students' feedback?

I have indicated that my study was two-fold. That is; it was focused on how I learn to teach biology and what I learn about teaching biology to pre-service teachers. The first two research questions are about learning from experienced teacher educators and focus on how and what I learnt from interacting with them. The third research question addresses my developing teaching practices as I report on the insights gained from doing the actual planning and teaching of a biology topic to pre-service teachers. In research question 4, I interviewed students about how I taught to look back at my learning. That is, I use the student feedback as a lens to look at my practice.

## 1.7 THE CONTEXT OF THIS STUDY

Understanding the context of the study is an important aspect if one is to understand and contextualise its outcomes in any academic research (Opie, 2004). In self-study, context influences the way we ground our pedagogical practices and the insights that are drawn from the practice (Samaras, 2011). I am therefore providing this section for the reader to understand the context in which the study took place as I refer to some aspects of the context in Chapters 4 to 7 in terms of how the context influenced the insights gained. I start by briefly describing the context in terms of the models of teacher preparation programmes, as reported in the literature. I then address the context of the Wits School of Education (WSoE). I then describe the context of the division[12] I was teaching in where LS III (the course that I was teaching) is located.

### 1.7.1 The teacher education context

Institutions have different ways of preparing pre-service teachers. There are two main models used to train pre-service teachers, namely the concurrent model and the consecutive model (Hellawell, 1985). Each of these models aims to give pre-service teachers both the content of a specific discipline and the knowledge and skills of teaching that specific content (Zuzovsky & Donitsa-Schmidt, 2017). The main difference between the two models is that in the concurrent model, pre-service teachers learn both the content and the knowledge and skills of teaching simultaneously as opposed to the consecutive model. However, there are two versions of the concurrent model. The first version of the concurrent model reported in the literature is the one where the students are taught the content by a subject specialist (lecturers in the science mainstream) and thereafter get the professional knowledge from teacher educators (Zuzovsky & Donitsa-Schmidt, 2017). In most cases, the pre-service teachers would attend the same classes with the mainstream students in the first two years then proceed to do methodology courses in the last two years. At the end of their preparation programme, they graduate with one teaching qualification –the B. Ed degree. In the second concurrent model[13], the pre-service teachers are taught both the content and methodology courses by the same teacher educators in the same faculty or school of education. In the consecutive model, pre-service teachers learn about teaching skills after obtaining a qualification

[12] At WSoE, they use the term division instead of department although they mean the same thing. Throughout the thesis, I will use the two terms synonymously.

[13] Nyamupangedengu (2015) called it the second concurrent model because the same lecturers who teach a content course would also teach a corresponding methodology course.

based on the teaching subject only (Musset, 2010). These models have implications for the kind of teachers that are produced in terms of their competencies depending on how teacher knowledge is conceptualised. Wits School of Education (WSoE) uses version 2 of the concurrent model.

### 1.7.2 The context of Wits School of Education

This study was located in the school of education at the University of the Witwatersrand (WSoE). As mentioned earlier, in this School, they adopted the second concurrent model. In this model, pre-service teachers learn the content through a content course as well as the skills for teaching the content, through "methodology" courses. Both the content courses and the methodology courses are taught by teacher educators. The focus of this study was on the content course: LS III, which is done by third- and fourth-year students as a major and sub-major, respectively. The LS III course is taught concurrently with its methodology component where pre-service teachers are taught ways of teaching it. Table 1.1 shows the organisation of the B.Ed. programme at the institution.

**Table 1-1**

**The WSoE B.Ed. programme**

| | **Year 1** | **Year 2** | **Year 3** | **Year 4** |
|---|---|---|---|---|
| Educational studies courses | Education 1 | Education II | Education III | Education IV |
| Teaching subjects | Major subject I | Major subject II | Major subject III | Major subject IV |
| | | Sub-Major subject I | Sub-Major subject II | Sub-Major subject III |
| Methodology courses | Secondary Methodology I for Major subject I | Secondary Methodology II for Major subject I | Secondary Methodology III for Major subject I | Secondary Methodology IV for Major subject I |
| | | Secondary methodology for sub-major I | Secondary methodology for sub-major I | Secondary methodology for sub-major I |
| Other professional courses | Becoming a teacher<br>New literacies for teachers<br>Mathematical Routes | | | |
| Teaching Practicals | Teaching Experience I | Teaching Experience II | Teaching Experience III | Teaching Experience IV |

Table 1.1 shows the progression of courses for the B. Ed curriculum and how each content course runs concurrently to its methodology. This context is important to understand how the course fits

into the broader structure. It also provided an idea of what students at WSoE do before enrolling for the third year major course.

### 1.7.3 The science division in the WSoE

The science division is one of the nine divisions found in the WSoE. This division is responsible for preparing NS senior primary teachers and LS and PS high school teachers. Table 1.2 shows the succession of courses for students who are either specialising in PS or LS.

**Table 1-2**

**Succession of courses in the WSoE science division**

| | 1st Year | 2nd Year | 3rd Year | 4th Year |
|---|---|---|---|---|
| Teaching subjects | NS I | NS II | LS III<br>OR<br>PS III | LS IV<br>OR<br>PS IV |
| Methodology courses | Secondary Methodology (Sec Meth) NS I | Sec Meth NS II | Sec Meth LS III<br>OR<br>Sec Meth PSIII | Sec Meth LS IV<br>OR<br>Sec Meth PS IV |

As seen in Table 1.2, there are corresponding methodology courses for every content course in the division. I was teaching in the LS III course, and another teacher educator taught the corresponding methodology.

The division has an administrative individual who deals with collating the marks and issuing of textbooks to students. This eases the work of a teacher educator. Since science involves learning through practical investigations, the division has two laboratory technicians – one is for PS and the other one is for LS courses. The technicians prepare the laboratories for practicals and are involved in recruiting demonstrators. They are also responsible for grouping students into the laboratories and allocating laboratory lockers with materials for each group of students in each lab.

The LS sub-division[14] is composed of five teacher educators (myself excluded) who all have PhDs. The teacher educators meet at least once a month to discuss issues around their teaching practices, student matters and administrative issues like deadlines for marks. All the teacher educators are involved in the teaching of both undergraduate and postgraduate (honours and master's courses)

[14] I am calling it a sub-division because there is a "conveyor" just like there is for PS.

courses. Some of these teacher educators are also involved in teaching LS topics in NS I and NS II. Furthermore, a teacher educator who teaches a content class would also take its methodology component, as the two must be aligned and should inform each other. Although I was not teaching the corresponding LS III methodology course, I was involved in it as a tutor.

## 1.8 THESIS OVERVIEW

Chapter 1 introduced the reader to the study. I articulated the motivation for this study using my autobiography and literature and outlined the research questions that guided the study. I also presented the context in which this study was based. Chapter 2 presents a review of the literature and conceptual framework on the concepts that are central to this study. Chapter 3 outlines the design of the study. The findings are presented in chapters 4 to 7. For each findings chapter, I present data collection procedures and analysis before presenting the insights. Chapters 4 and 5 deal with the different ways of learning to teach biology to pre-service teachers that I explored in this study. Chapter 6 deals with insights about the principles of planning to teach biology to pre-service teachers. In Chapter 7, I present insights that emerged from student feedback on my teaching as I looked back and assessed my practice. Chapter 8 is the conclusion. It summarises the main findings of this study and recommends areas that may require further exploration.

# CHAPTER 2: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

## 2.1 INTRODUCTION

The literature review is the pillar of any academic research because it gives the researcher a sense of what is known and where the gaps are in the literature central to that study (Randolph, 2009). It guides the researcher on how to discuss the findings. Loughran (2005) notes that engaging in self-study "revolves around dilemmas of practice" and addressing teacher education pedagogical concerns (p. 27). These dilemmas and pedagogical concerns emanate from different points of practice that at times may seem discrete or rather difficult to form a 'whole'. In self-study, it is therefore, more meaningful to treat the full literature review as the conceptual framework. This is because the nature of self-study methodology requires multiple sources of data (Samaras, 2011). The multiple sources of data then call for multiple lenses that cannot be represented in the form of a diagram or a paragraph, but rather in the form of literature review presented at appropriate points throughout the study. In this chapter, I review the literature that is central to my study. The review process was informed by the objectives and research questions that guided the study. The title of my study is "Learning to teach Biology to pre-service teachers: A self-study" and the overarching research question was: **"How do I learn to teach biology to pre-service teachers?"** This research question had four sub-questions:

1. What do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?
2. How do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?
3. How does planning and teaching a biology topic help me learn to teach biology to pre-service teachers?
4. What knowledge about my teaching do I gain from students' feedback?

The central idea that runs through the research questions is: "How I learn" but how I learn is also influenced by what I learn. The study was also about the pedagogies of teaching pre-service teachers that were revealed by how I learnt to teach. In this literature review chapter, I start

operationalising the term "learning" and discussing what learning to teach means in my case by drawing from several theoretical learning approaches that have been proposed in previous studies. I then discuss the role of self-study as a methodological stance and the significance of reflection in learning to teach. In this study, the concept of *learning* is in two dimensions: my learning to teach as the researcher and the learning of the students I taught. As such, in Section 6 of the chapter, I present the literature on the teaching and learning processes in pre-service teacher programmes and particularly, biology. In Section 7 of the chapter draws from the pedagogical content knowledge (PCK) construct to discuss the literature on the knowledge of teaching for teacher educators. The last section briefly discusses the notion of teacher educator professional identity.

## 2.2 THE PROCESS OF LEARNING TO TEACH

As indicated in Chapter 1, the primary objective of this study was to look at how I learn to teach biology to pre-service teachers as a novice teacher educator. The concept of learning is complex and difficult to define because firstly, there are three dimensions to it: the psychological, social and neurological and secondly, its *nature* is varied in the sense that it is at times attributed to an outcome or a process (Brown, 2015). However, there are various theories explaining learning. These theories range from behaviourists' to constructivists' perspectives. The behaviourists' perspective attributes learning to a change of behaviour mainly as a result of experience and the stimulus-response mechanism (Gregory, 1987; Skinner, 1985). Cognitivism as one dimension of constructivism attributes learning to the utilisation of tools and explains the role of the mind (Piaget, 1965). The more social constructivists' perspectives attribute learning to social processes (Vygotsky, 1978) while situated cognition stresses that learning takes place in situated contexts (Lave & Wenger, 1991). All these theories can help us understand and operationalise the concept of learning.

Behaviourism as one of the earliest theories of learning, established by Watson and Skinner drawing on Pavlov's work, emphasises that learning is a result of the change of observable behaviour (Bush, 2006; Skinner, 1985). This means in cases where there is no observable behavioural change, learning has not taken place. Although Rotfeld (2007) claimed that the theory of behaviourism was put forth as a basis for prediction and testing; this theory also contributed to theorising the process of learning. For example, the early works of Gagne looked at learning in the context of military training drawing from the behaviourist theory of learning (Gagne, Briggs &

Wager, 1992). However, the behaviourist theory fails to explicitly explain the role of individual cognition and thinking because the emphasis is on the provision of stimuli to reinforce certain behaviour (Sajdak, 2013). In my study, I observed experienced teacher educators' behaviours in their practice, but the observations were accompanied by my perceptions, personal theories, and contextual influences. Therefore, my study does not draw from the behaviourist theory. The behaviourist theory seems to stress that learning is best perceived in terms of outcomes instead of the process (Pritchard, 2009) The bulk of how I learnt and what I learnt was influenced by cognition and engaging in situated and social activities. In this study, I, therefore, drew from principles of two theories of learning, experiential learning theory and situated cognition. The two theories are rooted in constructivism. Below, I discuss how the two theories fit my study.

### 2.2.1 Experiential learning theory from a constructivist perspective

The first theory that I drew from is the theory of experiential learning. Teaching is a practical activity. Therefore, I consider learning to teach as an experiential endeavour. The experiential learning theory was conceptualised by Kolb (1984) as an adventurous and reflective learning approach drawing from the scholarly work of Dewey (1938, 1971) and Piaget (1966). This theory takes into account constructivist approaches and articulates the central role of experience in learning (Brown, 2015; Kaufman, 1996). For Kolb (1984), learning can be defined as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (p. 41). Kolb's definition of learning emphasises the role of individuals' cognition as they need to take in information, interpret it and look at how it can be useful in their contexts. This definition disregards the notion that learning is an acquisition of readily-made content. Hence, its foundation is constructivist, where the one who learns becomes an active participant in making meaning. The model of this theory is presented as a four-stage cycle showing how reflection can be used as a tool to translate experience into guides for active experimentation. The link between these four stages is therefore about acquisition and transformation as an individual responds to what is observed or experienced (Kayes, 2002). The four stages are described below.

The first stage is concrete experience and it is dialectically related to the third stage called abstract conceptualisation (Kemp, 2010). As Kolb (1984) says "learning is best facilitated in an environment of concrete experiences" (Kolb, 1987, p. 9). The essence of learning is in the process

that is characterised by an individual's conceptualisation and analysis of connected concrete experiences. Concrete experience and abstract conceptualisation are the modes of acquisition of knowledge (Kemp, 2010). In the concrete experience, the individual is exposed to complex situations that count as information. In abstract conceptualisation, the individual has to make meaning out of these experiences through reflection and organising the information. In my study, the concrete experience involved observation of experienced teacher educators and doing my actual planning and teaching of the course. Abstract conceptualisation involved reflecting on my experiences as an undergraduate student. It further involved making sense of the information about teaching biology to pre-service teachers gathered from observations of experienced teacher educators. It should be noted that even in the acquisition of knowledge, reflection is the key process as it helps an individual develop higher-order thinking skills and generate more information through transformation modes (Girvan, Conneely & Tangney, 2016). I was therefore both an information receiver and creator as I learnt to teach biology to pre-service teachers.

The other two processes explain the mode through which experience is transformed. These are reflective observation and active experimentation (Kolb, 1984). Reflective observation is of new experiences, and active experimentation means transformation and application of the knowledge in the context. Experience is transformed through reflective and active experimentation because experiences are the most important for learning as one shifts knowledge structures for development (Oleson & Hora, 2013). As Jarvis (2006) argues, a person is transformed through engaging in the reflection of experiences for learning. The transformation is about developing new understandings of practice. Through the planning of my teaching, there was an element of abstract conceptualisation that emanated from the concrete observations and discussions that happened through the involvement of the experienced teacher educators as experts. An important point to note here is that I regarded my learning as a process. It is a process that is reflective, constructive, situated and cultural in the teacher education space (Bell & Mladenovic, 2015; Harvey, Coulson & McMaugh, 2016).

As indicated earlier that learning can be defined from a range of perspectives. I drew from some of the perspectives. I will now discuss the perspective of situated learning and illustrate how my study is underpinned by elements of this perspective.

### 2.2.2 Situated learning from a constructivist perspective

Lave and Wenger (1991) constructed the theory of situated cognition and argued that learning is situated and a process that exists in-context where individuals learn as they participate in specific environments with social and cultural norms. In this study, I also considered learning as situated, that is, it takes place in both formal and informal settings, as teaching is learning in practice (Lave, 1996; Lave & Wenger, 1991). The formal settings are characterised by a Community of Practice (CoP). Lave and Wenger (1991) define CoP as a group of people sharing common interests and goals whose aim is to develop knowledge and themselves, both personally and professionally. New members enter a CoP as legitimate peripheral participants and gradually move towards the centre as participation continues (Hung & Chen, 2001). Skills and norms of that periphery can also be acquired through the process of apprenticeship. The process of cognitive apprenticeship means that as individuals do the *work*, they also think of what they do.

According to Lave and Wenger (1991), a CoP should have three components, namely; domain, community, and practice. In this study, I considered the domain to be teacher education in which myself, as a novice teacher educator, learnt to teach while the experienced teacher educators facilitated my learning. The repertoire of practice included the teaching and learning context and the teaching and learning resources and approaches. Learning involves the whole individual as knowledge is constructed within interactions and relationships that exist in the social spaces (Lave & Wenger, 1991; Wenger-Trayner and Wenger-Trayner, 2015). The assumption in this is that the experienced teacher educators have already moved to the centre of the CoP and hold considerable knowledge and skills needed to help those who are still entering or have just entered. When a novice teacher educator enters the teacher education programme as a new context, they are faced with knowledge, skills, and practices that they need to acquire. Learning, in this case, becomes situated because some practices are specific to the teacher education context or as in this case, specific to science teacher education. When an individual is provided with an opportunity to practise the culture and behaviour of the participants who happen to be experts, learning becomes a constructive and enculturation process (Fenwick, 2001; Mughal & Zafar, 2011). Hence, learning to teach is a dynamic sense-making and resolution of experiences, encounters, observations, and actions including those of the one that is learning. In this study, I viewed learning as a socially negotiated process underpinned by the way I responded and dealt with situations that are rooted

within observations, discussions, and actions, which in turn develop my understanding of the practice of teaching pre-service teachers.

I have now discussed the notion of experiential learning and situated cognition perspective. Experiential learning promotes ownership of the learning process by the one who is learning and emphasises the role of experiences. Situated cognition emphasises that learning is contextualised in communities of practice. Both these theories echo elements of self-study as a methodological approach to learning to teach. In the section below, I discuss how self-study is an appropriate methodology when one is learning to teach.

## 2.3 SELF-STUDY AS A METHODOLOGICAL APPROACH IN LEARNING TO TEACH

Self-study is emphasised as a methodology that provides an opportunity for teacher educators to engage in "critical examination of the self's involvement both in aspects of the study and in the phenomenon under study" (Kosnik & Beck, 2008, p. 117). Firstly, it is understood from the literature that self-study allows teacher educators to study themselves and document their learning experiences (Hamilton & Pinnegar, 2014; Samaras, 2011). Secondly, in documenting their experiences, these teacher educators are provided with opportunities to reveal and make public the tacit knowledge that they possess about teaching (Pinnegar & Hamilton, 2009). As such, experienced teacher educators have been engaging in self-study to not only understand and learn from their practice but to also improve it and improve the learning of the pre-service teachers (e.g. Nyamupangedengu, 2016, Nyamupangedengu & Lelliott, 2018; Sharkey, 2018). Besides the engagement in self-study of experienced teacher educators, the focus has now shifted to novice teacher educators for different purposes in addition to understanding practice. Self-study, as a methodological approach, offers possibilities of gaining new insights about the practice and exploring an individual's learning.

Engaging in self-study helps teacher educators to understand their practice and enhance their reflective skills (Laboskey, 2004). As Mena, Clarke, and Barkatsos (2016) indicate, teacher educators' enhanced self-reflective skills are important in teaching because reflection provides a means for accessing the knowledge for teaching. Williams and Power (2010) engaged in self-study to enhance their skills of reflection and to further use these reflective skills in understanding their

job as novice teacher educators. This helped them to begin identifying and analysing issues, concerns, and dilemmas in their practice. Part of Stump, Peercy and Bullock's (2018) project was also to understand the methodology of self-study as a transformative approach to learning. It is evident that science and other subject teacher educators engage in self-study for a variety of reasons. However, the ultimate goal is to improve practice through critical reflection. Engagement in self-study foregrounds reflection and experiences. In the following section, I discuss how reflection is key to learning how to teach.

## 2.4 REFLECTION AS A KEY PRACTICE IN LEARNING TO TEACH

The term reflection is ambiguous and understood differently by different scholars (Zeichner & Liston, 1996). However, when Dewey first made use of the concept in the early 1930s, he described it as a specialised form of thinking to understand situations and practice (Finlay, 2009). Ragoonaden (2015) emphasises that this specialised form of thinking needs to go beyond understanding to improving practice. As a tool, reflection is embedded in reflective practice. Reflective practice is an engagement approach where teachers study their teaching by continually reflecting on what they do, their experiences and observations (Earl & Ussher, 2016). Lane, McMaster, Adnum, and Cavanagh (2014) argue that reflective practice allows teachers to learn from what they do. Teachers identify events and incidents that are points of reflection to draw insights for their learning. In the self-study of science teacher educators, improving practice involves improving teaching approaches for pre-service teacher learning. Other scholars like Jarvis (1992; 2006) view reflection as a continuous process. In this process, as teacher educators, we learn and gain insights from our practice. Teacher educators further get an opportunity to refine our actions embedded in the practice.

Dewey's understanding of the concept of reflection informed Schon's (1983) differentiation between reflection-on- and reflection-in-action. What became the main gist for Schon was the concept of reflection-in-action as he argued that it is the core of "professional artistry". By professional artistry, he meant the ability and opportunity of practitioners to modify their practice as they think through their actions. In other words, reflection-in-action means reflecting as the incidents happen. Modifications in my practice, throughout my study, were informed by my reflections and how I later responded to and learned from the reflections. Teacher educators can

also reflect after an incident/event to modify the next action. This is what Schon termed reflection-on-practice.

Reflection involves critical introspection, while key aspects of practice are questioned. In addition, reflection is central to the concept of self within practice because its tacit thoughts are brought to the awareness of the self and those around you as a practitioner (Farrell, 2011; Lane et al., 2014; Sweigard, 2007). In my study, I kept questioning my ideas, emotions, behaviours and every action that I took as I was looking at teaching biology to pre-service teachers. My questioning helped refine my understanding of some aspects of teaching biology to pre-service teachers. Therefore, the notion of reflection should not be seen as just a training tool but as a significant *process* where teacher educators get to question and understand the uncertainties of professional knowledge in teacher education (Loughran, 2011; Zeichner, 2006).

To this point, I have presented literature that underpins the first dimension of my study – my learning as a novice teacher educator – by discussing the perspectives of learning theories and learning to teach using self-study. The second dimension of my study deals with teaching pre-service teachers; for which teaching cannot be separated from the students' learning. The three sections to follow deal with the literature reviewed on teaching and learning in teacher education; particularly the teaching of biology, including the knowledge that one requires to teach.

## 2.5 TEACHING AND LEARNING IN PRE-SERVICE TEACHER TRAINING PROGRAMMES

Teacher education, used in the context of describing where teachers are trained, evokes an environment that any teacher educator needs to understand to effectively teach the pre-service teachers because there are certain ways of doing things as governed by the professional knowledge, skills, and goals (Akyeampeng, 2017). According to Berry (2008), the knowledge for teaching teachers is a form of specialised expertise in academia, and it is different from the knowledge for teaching disciplinary subjects. As such, teachers who teach teachers require more than just the subject matter knowledge. The processes of teaching and approaches that teacher educators use should be well-grounded and accounted for (Loughran & Menter, 2019). Teacher educators' knowledge of teaching science pre-service teachers impacts the pedagogies employed during

teaching. In this section, I present literature on the learning agenda of pre-service teachers and how it informs the role and practice of the teacher educator.

### 2.5.1 Pre-service teachers' learning agendas

According to Loughran (2006), learning agendas are those key aspects that students of teaching should learn. Loughran (2006) identifies three learning agendas for pre-service teachers that teacher educators need to take into account. Firstly, students should learn about the specific content taught. Secondly, they should learn about learning. Thirdly, they should learn about teaching. The first agenda is concerned with pre-service teachers understanding of what is taught. This can be the professional knowledge of what it means to be a teacher or the subject matter knowledge of a specific teaching subject like science. This means that for a teacher educator to fulfil this agenda, they need to have a robust understanding of the subject matter knowledge that is taught to the pre-service teachers. This study focused on biology content knowledge. Therefore, my understanding of biology content was significant to fulfil this pre-service teacher's learning agenda.

The second agenda is about pre-service teachers' understanding of what it means to learn (Loughran, 2006). It also includes knowledge of how learning occurs. This means; the pre-service teachers learn about strategies for learning and theories of learning. This agenda is concerned with the teacher educator equipping the pre-service teachers with the knowledge of the skills and strategies for learning. The content of learning about learning can be included in educational courses designed to equip pre-service teachers with professional knowledge of teaching. Learning about learning or understanding learning involves an individual's metacognition and reflection as students think of what they learn, how they learn it and how the others (learners) would learn it. Metacognition would put students in the process of questioning their thinking and being aware of how their cognitive structures change for further learning (Hoban, 1997). When students are involved in metacognition, they would firstly question their approaches to how they learn and come to understand the content and secondly get to understand how what they learn can best be learnt by their learners.

The last learning agenda is about learning about teaching (Loughran, 2006). Pre-service teachers should learn about enacting the knowledge that they have gathered. This learning agenda involves the pre-service teachers learning the methods of teaching in their contexts of teaching (Loughran, 2006). For a biology teacher educator, this means assisting the pre-service teachers to acquire the

knowledge of teaching regardless of whether they are in content or a methodology course. Loughran (2006) indicated that a teacher educator must help the pre-service teachers acquire the knowledge linked to these three learning agendas as this is what differentiates them from other students.

The learning agendas, as noted by Loughran (2006), can be linked to the knowledge that the pre-service teachers must possess. Gitomer and Zisk (2015) stress that teacher knowledge has been the key component in pre-service teacher preparation, and teacher education has been striving to understand what this knowledge constitutes. This knowledge allows teachers to carry out the work of teaching. Thus, teacher knowledge is the critical competency that biology teachers need to have. The term teacher knowledge is used in this study to refer to the knowledge of teaching biology to learners. Some scholars understand teacher knowledge as the theory of teaching that pre-service teachers learn in their programmes (Carter, 1993). This theory can be about what it means to be a professional teacher. Other scholars see teacher knowledge as something that teachers can talk about and show practically (Toom, 2012), while others argue that this knowledge is a personal construct and is the basis of the teaching profession (Clandinin & Connelly, 2000). These three conceptions of teacher knowledge overlap and an ideal teacher needs to have all three. The main context of this study is the teaching of biology to pre-service teachers. This is the context that guided my thinking around the competencies and expertise that biology teachers need to have.

### 2.5.2 The dual role of the teacher educator

Korthagen (2001) described the pre-service teacher preparation programme as a problematic enterprise to denote its complexity in terms of the work of teaching involving pre-service teachers. As noted earlier, this is because there are complex agendas for both the teacher educator and the pre-service teachers. Teacher educators have a dual role when teaching pre-service teachers. The dual role for the teacher educator involves thinking about the pre-service teachers as students of Higher Education Institution (HEI) and thinking about them as future teachers (Russell, 1997). Therefore, the teaching of pre-service teachers goes beyond just presenting the knowledge of teaching to them. The dual role of the teacher educator is explained by the concepts of content turn and pedagogical turn. Loughran (2006) described content turn as an act of teaching the content knowledge of teaching. This involves teaching about classroom management and curriculum. In a biology content classroom, content turn would mean teaching the biology content knowledge.

Pedagogical turn has to do with the teacher educator thinking carefully about the approaches and practices that must be used to present the content knowledge. Therefore, both the teacher educator and the pre-service teachers must pay attention to how the knowledge is taught (Korthagen et al., 2005).

The two terms; content turn and pedagogical turn, were used to describe how teaching should be done in a methodology course where the pre-service teachers learn the content of methodology of teaching and how to use that content. These terms are also applicable in a content course. It is given that a content turn would be evident since a teacher educator would be the content of a specific subject. However, what is often neglected is the *pedagogical turn*. Teacher educators are not just teaching professionals but teachers who teach about teaching. Since the pedagogical turn has to do with the teacher educator consciously thinking about his or her approaches and teaching styles, this needs to be portrayed to students of teaching (Loughran, 2007). Therefore, the teaching of pre-service teachers is not only about the science content knowledge but also about the pedagogies of teaching the subject matter that needs to be shown during the lessons.

In this section, I have discussed teaching in pre-service teacher programmes. My study was about learning to teach biology to pre-service teachers. In the next section, I present literature on the teaching of biology to pre-service teachers.

## 2.6 TEACHING BIOLOGY TO PRE-SERVICE TEACHERS

I have indicated that teacher educators have a dual role to play in preparing pre-service teachers. It is also crucial to note that the nature of teaching and learning in pre-service teacher training varies according to what is being taught. In other words, the way a methodology course is taught may be different from how a content course is taught. Also, the way a language subject, for example, is taught would be different from how a science subject is taught and learnt. This section discusses how biology content can be taught to pre-service teachers.

### 2.6.1 Teaching biology using a constructivist approach

Careful attention first needs to be given to how students learn to understand the effectiveness of the practice of teaching in the classroom. Students learn when they are actively engaged in the teaching and learning space (Cakir, 2008). This means a teacher needs to adopt approaches that

promote active engagement and collaboration. These approaches are underpinned by the theory of constructivism as a guide to teaching and learning of science. A constructivist approach to teaching as developed by Vygotsky (1978) stresses that teaching should involve assisting students instead of transmitting information to the students. The aim of teaching is to help the students construct knowledge so that they develop cognitive curiosity (Berthiaume, 2009).

Firstly, since learning takes place when students restructure their thinking while incorporating what they already know about science concepts (Leach & Scott, 2003), teaching pre-service teachers using a constructivist approach involves acknowledging and using student prior knowledge (Ell, Hill, & Grudnoff, 2012; Glogger-Frey, Deutscher & Renkl, 2018). The idea of student prior knowledge is central to the constructivist way of teaching. Student prior knowledge is the knowledge they have acquired in the past from experiences (Sobat, 2003). According to Nyamupangedengu and Lelliott (2018), teacher educators need to be thought of during the planning of lessons. Furthermore, Darling-Hammond, Flook, Cook-Harvey, Barron & Osher (2019) and Hamza & Wickman (2008) indicate that the awareness of this prior knowledge provides the teacher with opportunities to think of instructional strategies that support student engagement for conceptual understanding. In teaching biology to the pre-service teachers, the teacher educator has to seek prior knowledge through questioning (Chin, 2007). At times, prior knowledge can be sought by using teaching and learning aids that trigger students' thinking. This practice requires a teacher educator to be a good judge of prior knowledge and decide how that knowledge can be taken up in the lesson such that the pre-service teachers learn both the content and how to teach that content.

Secondly, since student learning is enhanced when there are interactions and engagement in the teaching and learning space (Chaiklin, 2003), the teaching of biology should make provisions for students to engage. Janssen, Tigelaar and Verloop (2009) argue that teaching that provides students with opportunities constitute pre-service teachers' learning with understanding. Therefore, how students engage and learn would be influenced by the surrounding individuals. Teaching biology in a constructivist approach should involve the use of instructional material to trigger student thinking and promote engagement. Ajaja (2013) suggests giving students concrete materials and models as one of the ways to engage learners with the content and explain abstract concepts in biology. When students interact with people for engagement, they co-construct knowledge, and

this will lead to more understanding of the concepts being taught (Kuh, Cruce, Shoup, Kinzie & Gonyea, 2008). Construction and administering resources like worksheets are important in teaching biology. The teacher educator should allow students to think, activities given should enable students to make meaning. In that way, they can use their schema in organising knowledge acquired from activities (Khoza & Nyamupangedengu, 2018).

Thirdly, since constructivism suggests that knowledge is socially-embedded and learning is mediated (Vygotsky, 1978), teaching biology using a constructivist approach requires the teacher educator to act in certain ways. The role of a teacher educator in this regard is that of a mediator and facilitator. Facilitation involves the provision of tools and letting students co-construct knowledge as indicated above, and mediation goes beyond just providing the students with tools but also assists them in learning the content (Lee & Hannafin, 2016). The assistance can come in many forms including open-ended questions for the students to explore, as the student should be able to perform the task or the activity that fosters self-regulated learning (Blake & Pope, 2008; Zimmerman, 2002). So, a teacher should scaffold students' learning by first identifying the students' needs and then trying to assist. This applies to the biology teacher educators because the primary goal of teaching content to pre-service teachers is for them to learn the content and to some extent, the methodologies of teaching.

Teaching biology using a constructivist approach is primarily to help the pre-service teachers learn the content of biology while they make use of prior experiences to understand the current content. I have indicated earlier that teaching biology to pre-service teachers also involves making the students aware of the effective instructional strategies for teaching biology content to their learners. I discuss the concept of modelling as a way of equipping the pre-service teachers with effective instructional strategies for teaching biology in schools below.

### 2.6.2 Modelling good practice to biology pre-service teachers in a content course

Practising what you teach has a greater impact on students than what you say to them especially in teacher education (Korthagen, 2001). In other words, students learn more from what the teacher does than from what the teacher says. Smith (2005) explains that it is not good enough to tell students of teaching about what good teaching entails. The pre-service teachers need to be *shown* as the teacher educator is teaching how they can adopt some of the teaching approaches.

In 1997, Tom Russell published a book chapter titled "Teaching teachers: How I teach is the message." This is a significant message to denote that teaching pre-service teachers is not only about teaching the content. It is also about showing what you teach as a teacher educator through modelling teaching practice for the pre-service teachers (Loughran & Hamilton, 2016). Loughran and Berry (2005) defined modelling as "doing in our practice that which we expect our students to do in their teaching" (p. 194) while Lunenberg, Korthagen and Swennen (2007) defined it as the "practice of intentionally displaying certain teaching behaviours with the aim of promoting student teachers' professional learning" (p. 589). What is common between these two definitions is that they focus on the professional development of pre-service teachers dictating the teacher educator's task – that of modelling practice as during the teaching of content.

Modelling involves thinking about the messages that are portrayed to pre-service teachers during teaching (Boyd, 2014; Russell, 1997). Teaching the pre-service teachers should involve using the methods and approaches that teachers themselves are encouraged to use in their own teaching. The teacher educator can only think about these pedagogies if they have thought critically about the content that is taught and selected powerful approaches and strategies for teaching that content. Nyamupangedengu and Lelliott (2016) found that modelling practice can be done through practising all the aspects of teaching that pre-service biology teachers need to practise when they are teaching. The authors also showed that not only the teaching approaches need to be modelled but also the caring behaviours.

According to Lunenberg et al. (2007), modelling has three main advantages. First, modelling enhances the professional development of pre-service teachers as indicated in the authors' definition. This advantage is similar to what Wood and Geddis (1999) have indicated – that modelling good practices to students is a powerful way for pre-service teachers to learn about teaching. Lunenberg et al. (2007) explained that in addition to reading about teaching, pre-service teachers' professional development is enhanced as they experience the teaching behaviours from their teacher educators. In addition, Nyamupangedengu and Lelliott (2016) indicated that modelling practice in a biology content course caters for the pre-service teachers' identity of future teachers. As the pre-service teachers see themselves as future teachers, they develop professionally and orientate their minds into the dynamics of teaching biology in schools. Secondly, it improves teacher education and the learning of pre-service teachers. The assumption, according to

Lunenberg et al. (2007), is that teacher educators would model effective and updated ways of teaching, therefore equipping the pre-service teachers with recent instructional strategies. These two advantages are centred on the student as a future teacher. It is important that in biology teaching, recent instructional strategies are modelled by a teacher educator to enhance the professional development of pre-service teachers so that they can effectively teach in the dynamic school contexts.

As much as modelling is advantageous to the pre-service teachers, it is also beneficial to teacher educators. This point is reflected in the third advantage of modelling that is centred on the "self" as a practitioner, that is, to improve the teacher educators' teaching practice. This is because as teacher educators model practice, they "expand their pedagogical repertoire" (Lunenberg et al., 2007, p. 589). As a result, this contributes to the knowledge base for teaching pre-service teachers. Although modelling is a skill that needs to be learnt, it requires on-going reflection and quest to learn from practice as it defines the identity of a teacher educator (Hogg & Yates, 2013). As teacher educators are modelling practice, they develop a sense of who they are and discover what they perceive as effective teaching and learning, and this builds the professional identity of the teacher educators.

Although modelling practice is significant in teaching pre-service teachers, it forms part of the complex knowledge, skills, and competencies that a teacher educator needs to teach effectively. In the section below, I review the literature on the possible knowledge base that could guide the practice of a biology teacher educator.

## 2.7 TEACHER EDUCATORS' KNOWLEDGE BASE FOR TEACHING BIOLOGY

I have argued in Chapter 1 that teacher educators, just like school teachers, need professional knowledge to teach effectively. It is, however, still unclear from the literature; what constitutes this knowledge for teacher educators and whether this knowledge is specific to a discipline like science. Pedagogical Content Knowledge (PCK) is widely known as the knowledge that guides teaching and learning (Kind, 2009). I discuss how PCK forms part of teacher educator knowledge for teaching pre-service teachers below.

### 2.7.1 PCK as a possible science teacher educator's knowledge base for teaching

Shulman (1987) described PCK as "the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful" (p. 15). In response to this school of thought, several researchers explored how it is enacted in the classroom and how it is measured (Barendsen & Henze, 2019; Nilsson & Loughran, 2012). In particular, Ball, Thames and Phelps (2008) have made an enormous contribution in theorising PCK in the context of mathematics and have consistently argued that the knowledge needed for teaching mathematics is mathematical content knowledge.

To my knowledge, not much is known about teacher educators' professional knowledge for teaching pre-service teachers. Some previous studies have demonstrated that PCK is the kind of knowledge that school teachers need to have to teach subjects such as English (Wu &Yu, 2017), Mathematics (Krauss et al., 2008) and Science (Kind, 2009) effectively. Recent developments around PCK, as the knowledge base for teaching, have shown that PCK is actually topic-specific. Mavhunga (2012), for example, provided evidence that PCK is topic-specific. In other words, the transformation of the subject matter is specific to the topic (Mavhunga & Rollnick, 2013). Mavhunga (2012) has included components of PCK such as curricular saliency, what makes a topic easy/difficult to understand, representations including analogies and conceptual teaching strategies. These components[15] are the lenses through which one's PCK can be judged. Hence Nyamupangedengu and Lelliott (2018) argued that the components are part of what a biology teacher educator uses in transforming the content for teaching pre-service teachers during planning.

Although the PCK construct was initially developed for school teachers, it is applicable to teacher educators. Scholars like Abell et al. (2009) and Goodwin and Kosnik (2013) indicated that teacher educators need to develop PCK for teaching pre-service teachers. One of the contributions in the field of PCK for biology teacher educators is Nyamupangedengu's (2015) study that has shown that the knowledge domains that underpin PCK for school teachers from Rollnick, Bennett, Rhemtula, Dharsey and Ndlovu's (2008) model can guide the teaching of science in pre-service

[15] In Rollnick et al.'s (2008) article, the components are actually manifestations. In this study, they will also be called manifestations because I used them as a lens to also analyse my teaching and pre-service teachers' feedback to my teaching.

teacher programmes. Nyamupangendengu has shown that for teacher educators, these knowledge domains exist in two levels, the school level and the university level. I describe these knowledge domains below.

### 2.7.2 The knowledge domains that teacher educators need to be aware of to effectively teach a science course

*Subject matter knowledge*

Shulman (1986) suggests the subject matter knowledge domain is one of the categories of teacher knowledge bases. He described it as the knowledge of a particular subject, and it is about how much the teacher knows about what he or she wants to teach. This is the kind of knowledge that is essential for the teacher to proceed with the selection of teaching approaches (Leach & Moon, 1999; Shulman, 1987). It also informs planning and assessment (Shulman, 1987). Rollnick et al. (2008) argue that subject matter knowledge is a pre-requisite to teaching. Although Rollnick et al.'s (2008) model used the term subject matter knowledge instead of content knowledge, their description seems to be aligned to that of Kind (2017) who used the term content knowledge to include facts about concepts. Knowledge of content encompasses subject matter knowledge as it includes the teachers' understanding. In this study, I subscribed to using the term content knowledge, emphasising the idea similar to Pitjeng-Mosabala and Rollnick (2017), that it is a "precursor" (p. 472) to a teacher's knowledge for teaching. For the science teacher educators, subject matter knowledge goes beyond the knowledge or content of the discipline to include theoretical aspects discovered through research (Loughran, 2006). It is important to have both the content knowledge for teaching pre-service teachers and the content knowledge that the pre-service teachers need to teach learners in schools (Nyamupangedengu, 2015)

*General pedagogical knowledge*

Gess-Newsome et al. (2017) and Rollnick et al. (2008) describe the general pedagogical knowledge domain as the knowledge of teaching approaches and teaching skills. It includes the knowledge and understanding of learning theories and the ability to use those theories to inform one's teaching approach. Shulman (1987) says that pedagogical knowledge has to do with classroom management as part of classroom dynamics and the selection of appropriate teaching strategies. Shulman's definition is similar to Liepertz and Borowski (2018), who added that it

includes assessment strategies. The choice of these strategies depends on the context and the understanding of the subject matter (Rollnick et al., 2008). Goodwin and Kosnik (2013) also listed this domain as one of the knowledge domains that teacher educators need and argued that it is the cornerstone to the development of pedagogy of teacher education. For the teaching of biology, pedagogical knowledge should be linked to the subject, and the topic taught. In other words, the selection of instructional strategies should be guided by the nature of the topic.

*Knowledge of students*

In this domain, the teacher has to know his or her students well. Knowing your students starts with knowing their learning abilities and their diversity (Rollnick et al., 2008). It also includes knowing areas that are difficult to understand and students' prior knowledge associated with that particular content (Park & Oliver, 2008). This also applies to teacher educators as they need to know the prior knowledge that pre-service teachers bring to class (Otero & Nathan, 2008). Goodwin and Kosnik (2013) encompassed the knowledge of students in the domain 'contextual knowledge'. They argued that it includes the understanding that pre-service teachers are adults and how they are taught should be sensitive to this matter. As indicated earlier, Nyamupangedengu (2015) argued that these knowledge domains exist in two levels, a biology teacher educator needs to have the knowledge of his students and the knowledge of his students' learners. The prior knowledge of pre-service teachers may include all the experiences gathered through the apprenticeship of observation as learners and the time they have taken in teacher education. Therefore, at times, the prior knowledge of my students may be similar to the prior knowledge of my students' learners. Knowing the prior knowledge that pre-service teachers bring to class is important to guide my interactions with the students as I would plan accordingly if the prior knowledge contains misconceptions.

*Knowledge of context*

The knowledge of context has to do with the factors which influence teaching in a particular situation (Rollnick et al., 2008). This includes class size and availability of resources. An important aspect of this knowledge base for any teacher educator is the class size. Most classrooms in institutions of higher learning have large numbers of students (Nicol & Boyle, 2003). Therefore, a teacher educator must be sensitive to this and be able to select suitable teaching approaches for

large classes. Some of these suitable teaching approaches for large classrooms include group discussions and using worksheets during lectures (Khoza & Nyamupangedengu, 2018). Using group work in large classes is a demanding task, and it is for this reason that it needs to be thoroughly planned (Griffiths, 2009). For meaningful interactions to happen, the teacher educator needs to be familiar with the setting of the lecture room and possible re-arrangements thereof. Not only do teacher educators need to be aware of their context but also the contexts in which their students could possibly teach (Nyamupangedengu, 2015).

### 2.7.3 Manifestations of PCK as a lens to look at classroom practice

Manifestations are lenses through which teacher's knowledge (PCK) can be seen in the classroom (Rollnick et al., 2008). The teacher knowledge domains described above manifest differently in different classrooms. The manifestations can be different in response to the teacher educators' approach, context, and the nature of the topic taught. I, therefore, discuss them as the basis for learning about teaching by science teacher educators.

*Representations*

The use of representations shows teachers' PCK for that particular topic. Therefore, representations work differently on various topics. Rollnick et al. (2008) argue that information about teachers' subject matter and how they constructed it is evident through the choice of representations and how these representations are used in the classroom. Representations include analogies and demonstrations. Davidowits and Rollnick (2011) state that teachers need to select representations based on the nature of content taught and the level at which one is teaching. For the biology content, the nature is whether the content is at the macro or micro level and whether it is abstract or concrete. For abstract concepts, representations like models would work effectively for students to grasp the concept.

*Curricular saliency*

This is about knowing the purposes of teaching a particular topic as well as how that topic fits into the whole curriculum (Geddis & Wood, 1997). Davidowits and Rollnick (2011) give us an example that teachers can show the knowledge of the curricular saliency through leaving certain topics/concepts to be taught later and specific reasons why they have left the topics/concepts. The justification may include the connectivity and build-up of concepts and why a certain concept has

to be taught before the other (Park & Oliver, 2008). Biology is a subject that is dense with inter-lined concepts. The teacher educators' understanding of how the concepts are linked to each other is important for student understanding. Furthermore, this understanding resembles how well the teacher educator knows the content knowledge of a biology topic.

*Assessment*

Assessment is significant in any teaching and learning situation (Schneider & Bodensohn, 2017). Assessment is both formative and summative. Formative assessment is known as assessment for learning where students are given tasks to help them learn and improve their thinking skills. This can be done through questioning during the lesson. Summative assessment is known as assessment of learning where students are given tasks of grading (Knight, 2006). Bryan and Clerk (2019) argue that assessment in higher education should be designed to improve teaching and learning such that students can start to see themselves as "learners". Assessing science students involves assessing the cognitive domains of knowledge, skills, and attitudes (Yager & McCormack, 1989). Since biology is a branch of science, the teacher educators' assessment practices need to involve the three cognitive domains of science. This would include doing practical investigations, writing theoretical tests and engaging in attitude-value laden assessment strategies like debates.

*Interactions with students*

This manifestation was added by Davidowits and Rollnick (2011). The manifestation refers to the interactions that occur in the classroom. These are the interactions between the students and the teacher, between the students and between the students and the content and/or learning material. The interaction can be used as a teaching and learning strategy to help pre-service teachers understand the content by maximising their participation. A teacher educator needs to be in control to influence the content and direction of the interaction. In biology teaching, interactions that occur can be seen in whole-class discussions and can be promoted through a variety of ways, including questioning (Chin, 2007; Khoza & Nyamupangedengu, 2018).

*Topic-specific instructional strategies*

These are topic-specific teaching and learning strategies used to teach the concepts that are difficult to understand (Mavhunga, 2012). The teacher must be able to select powerful strategies to suit the content and context using the knowledge of context and general pedagogical knowledge. Mavhunga and Rollnick (2011) argue that these strategies should be conceptual in a way that they are selected to confront certain misconceptions as well as encouraging student participation. As a teacher educator, the instructional strategies used have to be selected appropriately as influenced by the nature of the content taught. Similarly, Shulman (1986) states that the pedagogies employed need to be more content-orientated than generic. Likewise, Berthiaume (2009) argues that teaching strategies in institutions of higher learning must be discipline-specific.

### 2.7.4 The role of pedagogical reasoning in teaching

In 1987, Shulman introduced the model of pedagogical reasoning and action to reveal the process that school teachers undergo in teaching learners - that it is a process of judgment, reflection and action. According to Bishop and Denley (2007), this model guides teachers in making decisions in teaching. Shulman (1987) argued that teaching "begins with an act of reasoning, continues with the process of reasoning" (p. 13). The reasoning is what reveals teachers' complex and tacit thinking and perhaps, the beginning of the restructuring of knowledge of what it means to teach

In the context of teacher education, pedagogical reasoning, and action guide the development of the pedagogy of teacher education (Loughran, Keast & Cooper, 2016). Pedagogical reasoning is significant for a biology teacher educator. Learning to teach biology to pre-service teachers should involve reasoning like a biology teacher educator, thinking like a biology teacher educator and acting like a biology teacher educator. The thinking, reasoning, and acting should be guided by the learning of pre-service teachers, as argued in Section 2.5 of this chapter. This is explained by the notion of pedagogical reasoning and action as a foundation for the development of professional knowledge for teaching (Loughran, 2019). The emphasis here is that teacher educators, like school teachers, are recognised as individuals of thought-in-context as they make pedagogical decisions. Loughran (2013) and Mansfield (2019) indicated that pedagogical reasoning involves making complex decisions that lead to the development of knowledge needed for teaching.

According to Shulman (1987), decision-making involves taking actions about the content of knowledge and teaching and learning approaches. He wrote; "teachers must learn to use their knowledge base to provide the grounds for choices and actions" (Shulman, 1987, p. 12) to

emphasise the role of reasoning that is underpinned by principles and experiences in teaching. I am taking the view that pedagogical reasoning and action is the foundation of teacher educators' practice. As Loughran (2013) argued, the act of teaching and pedagogy "demands attention to the reasoning" (Loughran, p. 122). The notion of reasoning cannot be ignored as it is the essence of teacher educators' practice of teaching pre-service teachers. Figure 2.1 shows the model of pedagogical reasoning and action as conceptualised by Shulman (1987). The components of this model are described below.

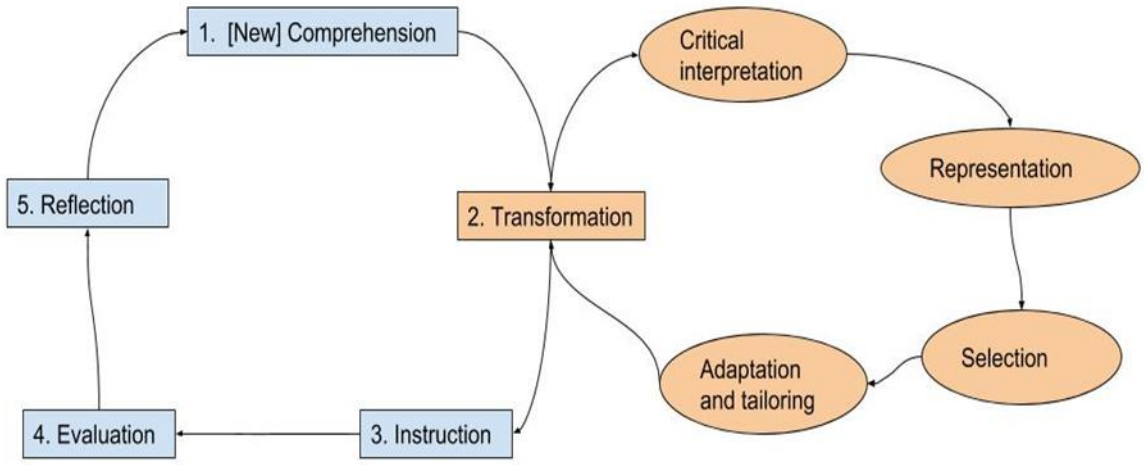



**Figure 2.1: Shulman's (1987) model of pedagogical reasoning and action**

*Comprehension*

Shulman said, "To teach is to first understand" (Shulman, 1987, p. 14). What he meant is that teachers need to have a strong content knowledge of the topic that they need to teach. Knowing the content knowledge involves being able to identify the main ideas of the topic and understanding how the concepts are linked to each other. Teacher educators need to know the core concepts of population ecology. They need to ask themselves the question: "do I understand this topic well enough to help others understand it?" and be specific to pre-service teachers. Mastering the content knowledge involves understanding the general pattern of the knowledge and understanding of particular aspects of the content as well. The former refers to the "vertical structure" of the content and the latter refers to the "horisontal structure" of the content (Shulman, 1987). This component is very important because it determines how well the transformation takes place.

*Transformation*

Transformation is the second component of the model of pedagogical reasoning and action, and perhaps a longer stage since a lot of thinking has to take place. This is where the teacher's pedagogical reasoning should be evident (Shulman, 1987). Transformation generally means how the teacher transforms the content knowledge gathered and understood during comprehension in ways that students can understand. Transformation involves several other stages, as shown in Figure 2.1 above. It starts with critical interpretation, then representation, then selection and ends with adaptation and tailoring. Each of these stages is important and emphasises critical aspects of planning to teach.

Critical interpretation involves the teacher planning how to represent and sequence the knowledge (Shulman, 1987). It also involves thinking about the mechanisms through which knowledge can be presented to students. The mechanisms in the context of this study include lectures, practical laboratory sessions, and tutorials. Once the teacher has a good understanding of how the content knowledge can be represented and sequenced, the teacher needs to think of possible tasks, teaching, and learning activities that are suitable to represent the knowledge. At this stage, the teacher educator interprets the content with the knowledge of students in mind. In other words, thinking about the students to be taught and the context within which they are to be taught is crucial.

The second step is representation. Representation involves thinking of the specific ways of making the content accessible to students. The representations may include metaphors, analogies, and demonstrations. Rollnick et al. (2008) argue that for a teacher to be able to do this, they need to have sound content knowledge. Having sound content knowledge helps the teacher in selecting specific representations for specific concepts of a topic. This step is linked to the third step, that is selection. Selection involves deciding on using specific representations and not the others (Bishop and Denley, 2007).

The last step is adaptation and tailoring. In this step, the teacher's thinking should be underpinned by the phrase "Thinking about THIS content in relation to THESE students." Thus, the knowledge of students becomes very crucial. What should guide the adapting and tailoring of the content knowledge is the knowledge of students and their context (Starkey, 2010). The teacher's thinking

should be guided by the students' interests, students' prior knowledge and misconceptions, the language of teaching and learning, and the language of science, including the vocabulary. This step also involves tailoring the tasks in such a way that they are aimed at developing students' understanding and consolidating their learning. Although the steps are represented as cyclic in the diagram above (Figure 2.1), they influence each other.

*Instruction*

Instruction is the actual presentation of the transformed content knowledge (Shulman, 1987). In the teaching process, there should be learning. In other words, the teacher should employ acts that lead to learning. These acts include facilitation and scaffolding in the learning process. This is where the tasks and the teaching and learning activities are presented to the students to help them learn the content.

*Evaluation*

Evaluation is the process that involves the teacher assessing the students' understanding of what was taught (Shulman, 1986). Evaluation involves both formative assessment and summative assessment. Formative assessment can be done through questioning or short tasks during instruction for students to receive feedback as they learn the concepts. A summative assessment is designed to grade the students (Lau, 2016). The teacher needs to think about these two forms of evaluation. This component still requires a strong understanding of the subject matter because it is the subject matter knowledge that is assessed.

*Reflection*

Reflection has to do with looking at what was done, stretching from comprehension to evaluation, and engaging in a review of the actions (Niess & Gillow-Wiles, 2017; Shulman, 1987). The process of reflection is a complex one because it involves the teachers revealing their vulnerability and being true to themselves (Kelchtermans, 2009). In this process, the teacher needs to decide on what happens in new comprehension. Therefore, it is important for the teacher to gain insights from what happened in the classroom both in terms of that specific topic and in terms of teaching specific students in general.

*New comprehension*

This is not different from the first form of comprehension that has already been discussed. The significance of this comprehension is for the teacher to use the lessons and insights gained from reflection to think about how the next lesson can be taught (Shulman, 1987). Because the next lesson may not be about the same topic, new comprehension involves thinking about the new topic. This thinking can be in relation to the same students or a different group of students. While the steps are represented cyclically, they are not cyclic when applied in practice. In fact, they are integrated. I have called them "components" instead of steps or phases to emphasise their integration and how each one of them influences the others. For example, reflection is useful in all the components. As the teacher thinks about transformation, reflection is involved because the teacher is engaged in the process of decision-making that requires looking at possibilities. At the core of this model are the processes of transformation and reflection.

### 2.7.5 The role of beliefs in learning to teach pedagogical decision-making

The concept of teacher beliefs is very complex (Bryan, 2012) because it is difficult to know how deeply rooted they are and how they are accumulated (Zheng, 2013). Bryan (2012) asserts that even if this is the case, beliefs play a vital role in teachers' pedagogical decision-making. My aim here is not to describe teacher beliefs in general but to give an overview of how I see beliefs as important to science teacher educators' teaching. Earlier, I indicated how beliefs are important in guiding our actions and influencing our experiences and the way we reflect on our experiences (Oleson & Hora, 2013). Action, in the context of this investigation, involves planning and teaching biology to pre-service teachers. According to Oleson and Hora (2013), beliefs play an important role in one's learning as they affect thoughts, practices, and how an individual identifies himself. In other words, practitioners' thinking about the past, present, and future is largely influenced by beliefs. Furthermore, Izadinia (2014) argues that beliefs are one of the core aspects of teacher educators' practice in developing their professional identities. Teacher educator beliefs are important in this study because, in my journey of learning, I questioned my beliefs and what I considered to be effective ways of teaching. The beliefs that are important to this study include what I consider to be the effective teaching of biology.

The notion of beliefs as influencers of what the teacher educators in the classroom contribute to the building of professional identity. Below, I discuss the notion of professional identity in learning to teach.

## 2.8 TEACHER EDUCATOR PROFESSIONAL IDENTITY

On a basic level, Gee (2000) defined identity as the way others see others, that is, how a person is perceived as an individual. Swennen, Jones, and Volman (2010) described teacher educators' identities in two forms: the teacher form and the research form. In this study, I talk about identity in terms of teaching. Professional identity in the context of teaching is defined as how teacher educators perceive themselves in the work that they are doing – the work of training teachers – including their interpretations of the interactions they have in context (Canrinus, Helms-Lorenz, Beijaard, Buitink, & Hofman, 2012). Dinkelman et al. (2006) argue that professional identity is something that is constructed over time; therefore "understood as a process of becoming" (p. 6). Some practitioners have studied themselves to find their professional identities as well as finding ways of being better teacher educators looking at the teaching role (e.g. Kitchen, 2005; Nyamupangedengu, 2015). Professional identity is central in self-study since self-study is about the self and exist in context. In this study I looked at how I learn to teach biology to pre-service teachers. In self-study, Palmer (1997) argues that identity is important because one constructs their practice and question their taken-for-granted thoughts. The 'self' is constructed and not found readily-made. In the construction of the 'self' in relation to practice, identity becomes significant. That is, how teacher educators see themselves in the context that they find themselves in (Olsen, 2008). This is why Clandinin, Connelly & Bradley (1999) and Kitchen (2016) assert that identity is socially and contextually asserted. The social context in this case is the community of practice that includes the experienced teacher educators and the pre-service teachers as Coia and Taylor (2009) argue that those that are taught influence the identity of those who are teaching. The significance of identity to my study resides in the fact that I was engaged in reflective practice in constructing my practice of teaching biology pre-service teachers.

## 2.9 CONCLUSION

In this chapter, I have presented a review of the literature that is related to the objectives of my study. The literature that I reviewed forms a conceptual framework of my study. This study was on how I learn to teach biology to pre-service teachers. My literature review was guided by my research questions. I reviewed the literature on the concept of learning to teach by drawing from mainly two theoretical perspectives of what learning means. I then discussed the role of self-study as a relevant methodological approach in learning to teach. It is clear from the literature that

reflection is a useful learning tool in learning to teach. I also reviewed the literature on teacher education since I am learning to teach pre-service teachers. I also reviewed the literature on models of teacher education to set the scene for the focus of my study. I then reviewed literature on teaching biology to pre-service teachers. Since teaching is guided by the PCK framework, I discussed PCK as a theoretical construct for teaching and learning. Lastly, I presented a brief discussion on the notion of teacher educator professional identity. This chapter offers a discussion of the relevant literature as a conceptual framework for this study.

The next chapter discusses the research design that was followed in this study. The chapter primarily focuses on why this was a qualitative research design by discussing the link between qualitative research design and self-study methodology and the data collection methods used.

# CHAPTER 3: RESEARCH DESIGN

## 3.1 INTRODUCTION

When using self-study methodology, the design of the study is often different from the "traditional" linear design where one would collect data, analyse, and write findings. In self-study, the design is different in the sense that the stages of research are interlinked and as a researcher and the researched, you move back and forth in making sense of the data and practice (Samaras, 2011). In other words, data collection and analysis begins once the problem or motivation has been identified. This is what Samaras and Freese (2006) called the hermeneutic nature of self-study. Therefore, although this chapter is conventionally used to describe the design and the methodology of studies, in this study, descriptions of data analysis are embedded in the findings in chapters 4-7. This chapter starts by discussing how this study was qualitative rooted within the interpretivist paradigm, utilising a self-study methodology. I then discuss the link between self-study and action research. This is followed by the use of narratives and narrative inquiry in self-study. I then describe the participants of the study. This is followed by a description of how data was generated. I then look at how I involved critical friends in carrying out this study and dealt with issues of trustworthiness. Lastly, I describe how I addressed ethical issues.

## 3.2 INTERPRETIVIST PARADIGM AND QUALITATIVE RESEARCH VERSUS SELF-STUDY METHODOLOGY

Educational research usually employs three approaches; qualitative, quantitative, and mixed-methods. Each of these approaches is rooted within a certain paradigm. A qualitative research approach is underpinned by the interpretivist paradigm where knowledge is subjective and constructed (Opie, 2004). Through qualitative research approach, the researcher is able to explore a situation or phenomenon deeply because of its interpretive and descriptive nature (Creswell, 2012). In this study, qualitative research was employed to explore how I learn to teach biology to pre-service teachers. The phenomenon in this study is learning by a novice teacher educator. In 2009, Pinnegar and Hamilton published a book entitled "Self-study practice as a genre of qualitative research". The title of the book indicates that self-study is a category of qualitative

research and underpinned by the interpretivist paradigm because researchers that employ self-study methodology are interested in finding meanings in social phenomena.

Qualitative researchers emphasise gathering data from naturally occurring phenomena. Most of the data is in words; dictating to the research to deeply analyse and explore meanings of the social issues. The methods employed under self-study are mostly qualitative and analysed qualitatively. However, in most qualitative research approaches, the researcher studies a specific phenomenon by first collecting then analysing the data (Cresswell, 2012). In self-study, there is a *coming-to-know* process where the researcher is an insider with the researcher's practice and the self as the researched (Samaras, 2011). The researcher *comes-to know* his practice by recognising and engaging in dialogue with himself and the practice (Pinnegar & Hamilton, 2009). In qualitative research, people, situations or certain phenomena should be studied to generate frames of meaning (Opie, 2004). This is also evident in self-study because the researcher seeks to find meaning in his practice and further improve this practice. What makes self-study more appealing and powerful as a research methodology, especially in education, is the use of "I" to make explicit the researcher as the researched in relation to practice.

## 3.3 ACTION RESEARCH AND SELF-STUDY: WHY IS THIS STUDY NOT ACTION RESEARCH?

When action research was introduced in the 1970s, it became and still is a prospective technique to solve practice-based problems (Ferrance, 2000; Hine, 2013). According to Kemmis and McTaggard (1992), an individual who is doing action research has to "plan, act, observe and reflect more carefully, more systematically and more rigorously than one usually does in life" (p. 10). This definition tells that the methodology of action research is spiral in nature. The researcher has to first identify the problem, plan, and act on the plan, reflect, plan again and act again and find a solution that encourages new generation of further problems. Action research as defined in terms of its purpose is an important form of research because it provides practitioners with an understanding of a problem or a concern (Opie, 2004; Taber, 2013).

Action research has influenced the methodology of self-study and the two are often confused (Bullogh and Pinnegar, 2001). Action research and self-study as a methodology have a lot in common. Firstly, they both have an element of inquiry that relates to practice or a quest to

understand and know something about practice. Secondly, they are both narrative in a sense that the researcher tells a story about how they came to know or solve the problem through reflection (Samaras & Freese, 2006). Self-study goes beyond action research in that it is not restricted to the problem-action cycle that guides action research. While action research is targeting a specific problem of concern (Taber, 2013), self-study does not have to be initiated by a problem (Samaras, 2011). Self-study is about wanting to improve practice or just merely understanding one's practice. The actions in practice are in most cases informed by the experiences that practitioners had. For this reason, self-study is not just focused on a specific problem therefore does not necessarily solve the problem but improves practice through 'self'. The emphasis of self-study is 'self' and 'practice' whereas the emphasis of action research is 'action' and the specific 'problem'.

## 3.4 NARRATIVE INQUIRY IN SELF-STUDY

Narrative texts stem from narrative research approach that aims at organising people's experiences and telling stories (Connelly & Clandinin, 1990). According to Kitchen (2009), in narrative inquiry, practitioners immerse themselves in practices as they tell the story of their lived experiences that they have reflected on. The re-telling of experiences is a multidimensional and multi-layered activity as one thinks of the past, present and the future. Furthermore, the interactions between the 'self' and the broader social context are important as they contribute to deeper understanding of the phenomena (Kitchen 2016; Clandinin & Connelly, 2004). Self-study uses narrative inquiry, as the study of experiences, in a sense that stories about a practice of an individual are told by the researcher (also the researched) using narrative texts. As such, self-study is grounded in inquiry and reflective action (Hamilton, Smith & Worthington, 2008). In other words, it evokes reflection of individuals on their practice. Self-study that takes a narrative form is about narrative expressions of life experiences allowing the researcher to construct meaning within the self in context. Self-study involves drawing insights from one's experiences because there is strike in balance between the 'self' (that is the practice) and the experiences that are contextual (Hamilton & Pinnegar, 1998; Bullough & Pinnegar, 2001). As such, in this self-study, I also drew from narrative inquiry elements. took a stance that is revealing and making explicit our experiences as teacher educators in collaborative environment.

## 3.5 PARTICIPANTS

According to Opie (2004), participants in educational research should be selected with care as guided by the purpose of the study. In this section, I describe the groups of participants who were involved in this study and show their relevance and contribution to this study.

**The researcher:** A self-study conceptualises the researcher as the researched within the practice. Furthermore, self-study is self-initiated in that the researcher decides to study his or her practice (Pinnegar & Hamilton, 2009). Due to this nature of a self-study methodology, I was the main participant in this study.

**The LS III pre-service teachers:** As indicated in Chapter 1, this study was about how I can learn to teach biology to pre-service teachers. This means LS pre-service teachers were participants of this study for two main reasons, firstly, because they were registered for the LS III course and, secondly because I collected data from them through interviews. There were 135 pre-service teachers registered for the LS III course at WSoE. Most of the students were in their third year of study while some were in their fourth year of study doing LS III as their sub-major subject. This group of students was composed of the four main races found in South Africa in general, and at Wits in particular: Black, Indian, Coloured, and White students.

**Biology teacher educators:** Six teacher educators were part of my study because I observed their teaching and continuously engaged in discussions with them about teaching biology to pre-service teachers. The teacher educators formed part of my validation group by giving me feedback on the analysis of my teaching practice and my reflections on what I observed in their classrooms. The discussions that emerged helped me learn and refine my practice. The teacher educators were chosen because they were experienced and were teaching biology in the same institution. The details of these teacher educators are given in Table 3.1.

## 3.6 DATA COLLECTION PROCEDURES AND IMPLEMENTATION

The self-study methodology requires one to collect data from multiple sources to increase the trustworthiness of the study (Pinnegar & Hamilton, 2009). Apart from increasing the trustworthiness of the study, I also chose to collect data from different sources so that I could increase my dimensions of learning to teach biology to pre-service teachers. I collected data from

six different sources: (1) Journaling, (2) Students' written feedback on my teaching, (3) Discussions with teacher educators (4) Direct observations of teacher educators, (5) Video- and audio-recording of my teaching and (6) Student interviews. Although descriptions of data analysis are incorporated in the chapters with the findings, analysis of data happened concurrently with data collection procedures as accompanied by certain practices like the generation of narrative texts. The data collection procedure was such that one would inform the other, as was shown in Figure 3.1.

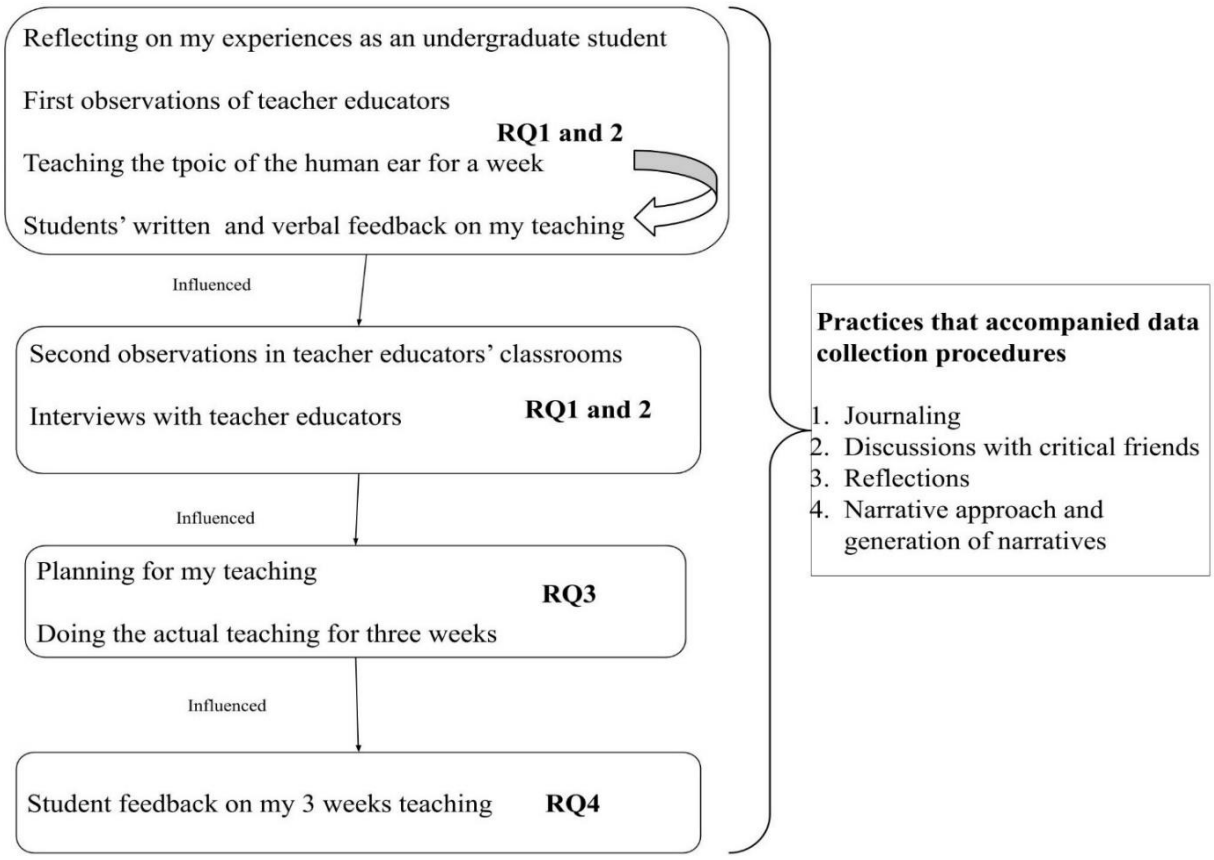



**Figure 3.1: A summary of data collection procedure and practices**

Figure 3.1 shows how one phase of data collection would influence the next. In the first box, there is an arrow to indicate how the student feedback obtained in the first lecture influenced my second lecture when teaching the topic of the human ear. As an example of how the data sources were interlinked; I entered my experiences as an undergraduate student (data set 1) and used insights from observed teacher educators' teaching (data set 4), to inform my one-week teaching of the human ear as a topic (data set 5) and my second observations of experienced teacher educators'

lectures (data set 4). My experiences from data set 1 to 4 informed my teaching of population ecology (data set 5) that then influenced what I recorded in my journal and student interviews. In the process of data collection, I was engaged in reflection, discussions with critical friends, journaling my reflections, and generation of narratives. The insights were drawn as data were collected and analysed. Hence data analysis approaches are incorporated in the chapters reflecting the findings. I describe in detail each data collection procedure (as depicted in Figure 3.1) and implementation below.

### 3.6.1 Journaling

According to King and LaRocco (2006), a journal is personal evidence of one's thinking and actions. These actions and thoughts are what might have happened, what is happening, and what will happen in the future. Journaling helps individuals to write interpretations and judgements about certain events, processes, and issues (Göker, 2016). When used in research, it offers the researcher an opportunity to engage in an inner dialogue and reveal inner thinking (Pinnegar & Hamilton, 2009). Since the inception of reflective practice and self-study, teachers have been using journals to record their observations and experiences about practice (Samaras, 2011). The journal can be shared with others for their perspectives which will, in turn, trigger the teacher's reflections. In this study, I kept the journal to record my experiences, thoughts, and observations of my practice of teaching pre-service teachers.

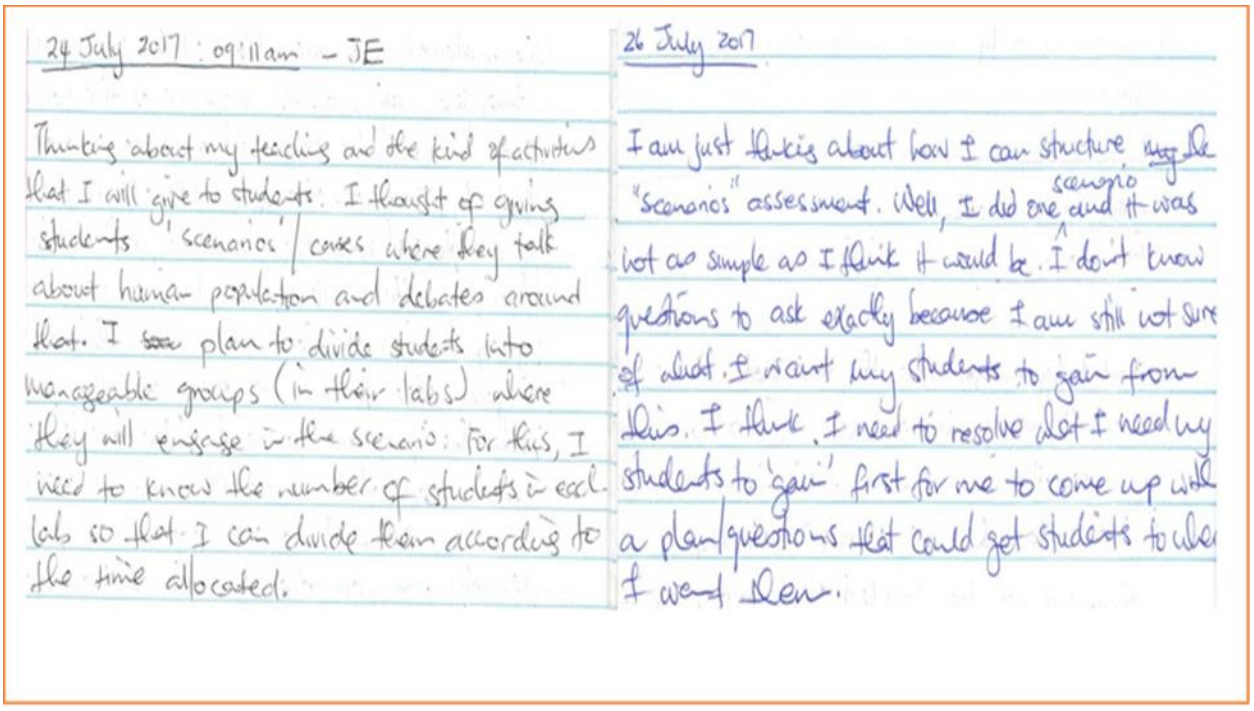
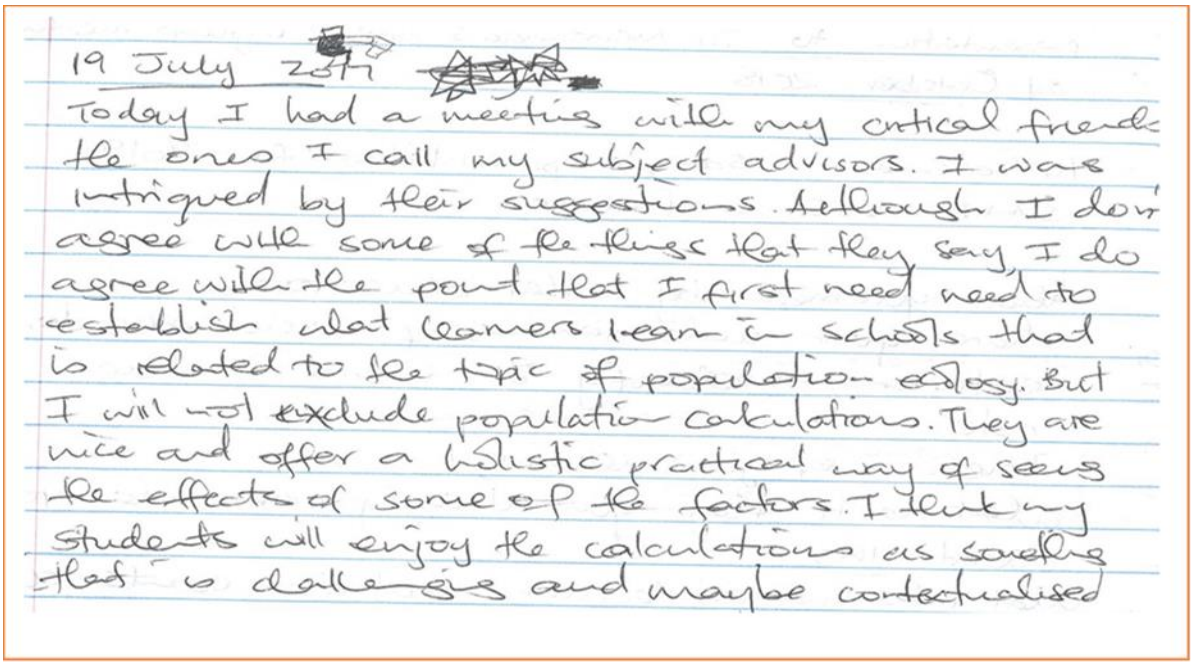



**Figure 3.2: Examples of journal entries that included teaching ideas**

My journal entries included my pedagogical ideas on teaching the human ear and population ecology to biology pre-service teachers (see an example in Figure 3.2 above). I kept the journal with me most of the time to record any thoughts that came to my mind at that time. Where I did not have the journal but had gadgets (e.g. phone), I would audio record what I was thinking and later on, transcribe the audio-recording into the journal.

I would regularly share parts of the journal (including the voice notes) for feedback from and perspectives of my critical friends (see Section 3.6.6) which were further recorded in the journal (see an example in Figure 3.3 below). Since I included everything in one journal, it became disorganised and was difficult to decode. In Chapter 8, I propose more organised ways of journaling when using self-study methodology to learn about one's practice


19 July 2017

Today I had a meeting with my critical friends the ones I call my subject advisors. I was intrigued by their suggestions. Although I don't agree with some of the things that they say, I do agree with the point that I first need need to establish what learners learn in schools that is related to the topic of population ecology. But I will not exclude population calculations. They are nice and offer a holistic practical way of seeing the effects of some of the factors. I think my students will enjoy the calculations as something that is challenging and maybe contextualised

**Figure 3.3: An example of a journal entry where I was responding to a critical friend's feedback**

### 3.6.2 Students' written feedback on my one-week teaching

Kember and Wong (2000) and Seldin (1997) notes that written feedback from students to their lecturers is a tool that lecturers can use to continuously improve their teaching. Unlike the generic questionnaires given to students to evaluate their lecturers' teaching, written comments provides more details about the students' experiences in the lectures (Samian & Noor, 2012). As part of my exploration, I taught the topic of the human ear for a week. In that week, I conducted three lectures of 1 hour each. After the lectures, I requested students to give me feedback on my teaching and their learning by writing it down on a paper. I did not give them the structure except the questions:

- What am I doing right that is helping you learn?
- What can I improve on that is making your learning difficult?

I asked them to write as much as possible and to be honest. I was mainly interested in how they perceived my teaching intending to get to understand how I could use their feedback to learn how to teach. In total, 68 students gave me feedback. The students wrote short responses. Two students willingly came to my office to give me the feedback verbally. I then transformed the students'

feedback into narrative texts by re-telling the story that was captured in their written and some verbal feedback. This was captured in the reflective journal.

### 3.6.3 Discussions with and observations of teacher educators

**Discussions:** In the CoP, discussions are important to help the apprentice learn about the practices and norms of the community (Hung & Chen, 2001). Furthermore, in self-study, learning from others would involve having continuous dialogue while reflecting to understand and improve practice (Koster & van den Berg, 2013). I wanted to learn from experienced teacher educators who have been teaching in higher education and/or teacher education for more than ten years. These teacher educators are members of staff in the Science Division of the Wits School of education. I continuously asked them questions about teaching pre-service teachers and the discussions I had with them were factored into the reflective journal. This was part of the informal discussions that I had with the teacher educators. I did not make appointments to ask them questions. In many cases, I would have a small discussion after observing their lecturers while I sometimes went to their offices to ask them questions and share my thinking. It was easier for me to do this because I had already explained to them about my study and what they can expect.

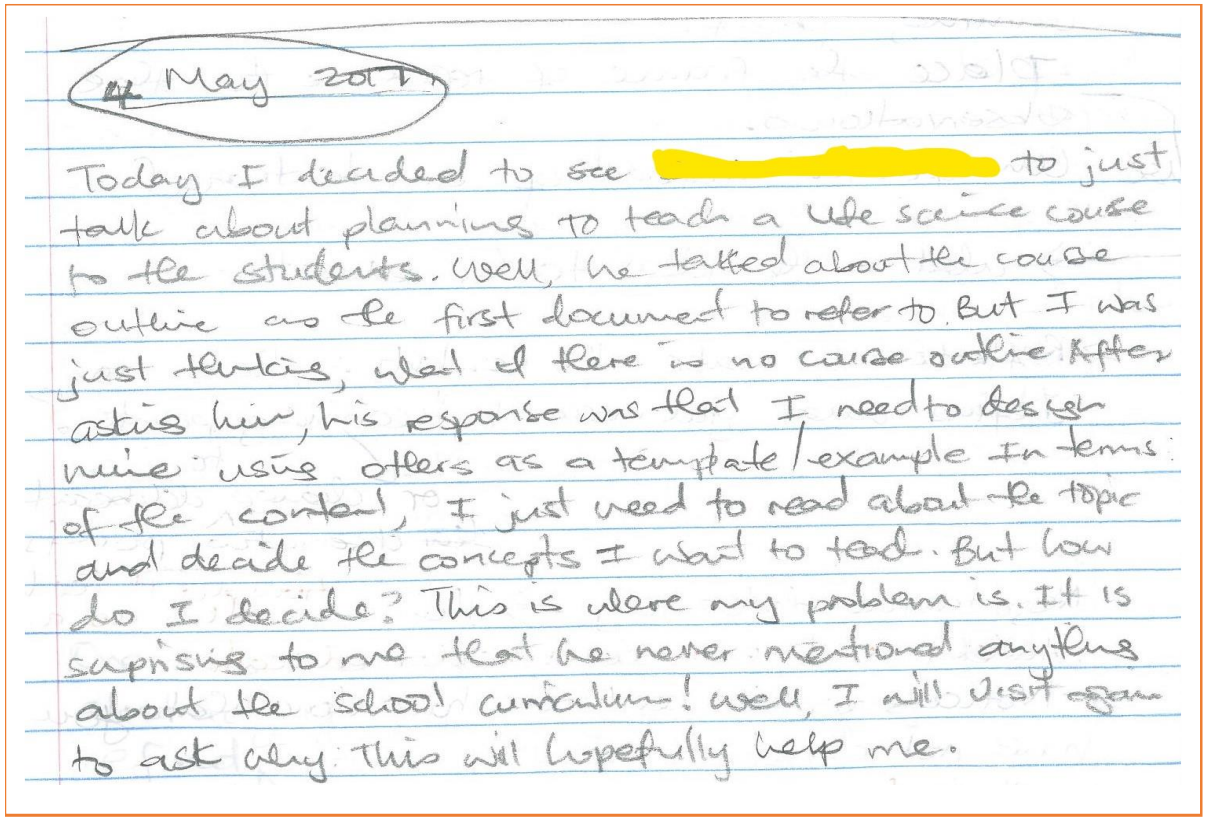
Prior to my planning to teach population ecology, I made appointments with four teacher educators to ask them about how one can plan to teach biology to pre-service teachers. Out of the six teacher educators I worked with, I had formal discussions with four (see Table 3.1). One question was asked to individual teacher educators: "How do you plan for your biology lectures?" and subsequent questions were based on the teacher educator's response leading to a discussion, as they also wanted to know my thinking. This format was similar for all four teacher educators. The interview excerpt below shows how the subsequent questions were formulated based on the teacher educators' responses and how the responses were interrogated to get a deeper meaning from their utterances.

**Interviewer:** *How do you plan for your biology lectures?*
**Leila:** *I was given the course outline; the approach would be, like to look at main points, then I would go and read around to get a solid understanding and see what to teach.*
**Interviewer:** *So, how far do you go about in terms of the content for pre-service teachers? So, let's say you are teaching plants. So with the BSc people, you would go very deep.*
**Leila:** *Yah, it would also depend on the year I am teaching.*

**Interviewer:** *Let's say you are teaching 3rd years, with pre-service teachers, how far would you go, what would guide your choice on how far you go with the content?*

**Leila:** *Oh yes, for sure, I can't just go with the CAPS. I need to go a bit deeper. Okay, one would be their textbook, their prescribed textbook. Maybe tell me about your thinking. What do you plan to do?*

I audio-recorded and later on transcribed the discussions. The interviews lasted between twenty-eight and forty-three minutes. All four interviews were completed within two weeks. The interviews were audio-recorded and transcribed verbatim for analysis. As noted above, this was more of a discussion than an interview because they would also ask me questions, opinions, and ideas of how I plan to teach the topic. This allowed me to think deeper and triggered my reflection. Although the primary data was the interview (discussion) transcript, I also had journal entries that reflected my thinking on these discussions. After each discussion, I did a journal entry where I summarised and reflected on what we discussed with the teacher educator. An example of such entries is shown in Figure 3.4 below.


4 May 2017

Today I decided to see [redacted] to just talk about planning to teach a life science course to the students. Well, he talked about the course outline as the first document to refer to. But I was just thinking, what if there is no course outline. After asking him, his response was that I need to design mine using others as a template/example. In terms of the content, I just need to read about the topic and decide the concepts I want to teach. But how do I decide? This is where my problem is. It is surprising to me that he never mentioned anything about the school curriculum! Well, I will visit again to ask why. This will hopefully help me.

**Figure 3.4: An example of a journal entry after an interview (discussion) with a teacher educator**

As indicated in the journal entry in Figure 3.4, when I did the journal entry, I still had questions. I, therefore, went to the teacher again to ask and share my thoughts. Hence, there were a lot of informal discussions and sharing of ideas with experienced teacher educators.

**Direct classroom observations:** Literature that advocates the significance of observations in educational research shows that observations can help a researcher to gather important information about what the teacher and learners do in the classroom (Creswell, 2012). In this case, the observer (researcher) gets first-hand information about what is happening in the classroom (Bertram & Christiansen, 2014). Sometimes an observer may need to write field notes to help him remember the specific incidents that took place. As noted by Orland-Barak and Leshem (2009), one can learn from observing others that do a similar job. Despite planned and unplanned discussions with the experienced teacher educators, I also attended their lectures to observe how they taught their pre-service teachers. Out of the six teacher educators I worked with, five were observed while teaching. Table 3.1 below illustrates the details of the observations and the teacher educators' number of years of experience in teaching in higher education. One lecture was fifty minutes long. The number of lectures observed is different from lecturer to lecturer due to factors like my availability and the time allocated to cover the topic. For example, when Mariam was teaching her topic, I was available to observe more of her teaching than when John and Gracious taught environmental studies and cell biology, respectively. The topics were taught and completed in 3 weeks. Alice lost three weeks of teaching time due to students' protests.

**Table 3-1**

**Summary of details of the observed and interviewed teacher educators**

| Teacher educator | Race and gender | Number of years teaching in HE | Topic taught | Number of lectures observed | **Formal discussion?** |
|---|---|---|---|---|---|
| Alice | Black Female | 11 | Homeostasis and temperature regulation | 3 (2 double and 1 single) | **No** |
| Mariam | Black Female | 10 | Nervous system and sense organs | 8 (4 double and 4 single) | **No** |
| | | | Genetics | 4 (3 double and 1 single) | |
| John | Black Male | 20 | Environmental studies | 4 ( 2 double and 2 single) | **Yes** |
| Leila | Indian Female | 14 | Evolution | 5 ( 2 double and 3 single) | **Yes** |

| | | | | | |
|---|---|---|---|---|---|
| Gracious | Black Female | 16 | Cell biology | 4 (3 double and 1 single) | **Yes** |
| Rose | White Female | 19 | Human reproduction | No classroom observations were done. | **Yes** |

As illustrated in Table 3.1 above, the teacher educators taught different topics to either third or fourth-year students. I only had a formal discussion with four teacher educators, however, I still interacted with the other two teacher educators informally, especially after the observations. These interactions were recorded in the reflective journal. The fourth method of data collection is described below.

### 3.6.4 Video and audio recordings of my lectures

Video-recordings and audio-recordings have been used as methods of data collection, mainly in qualitative research (Opie, 2004). The significance of these two data collection methods in qualitative research is that, as a researcher, you get rich data for an in-depth analysis, which tends to give an overview of the phenomena investigated (Opie, 2004). In addition, you get to understand the exact specific words that the participants used. Thus, the data is rich and authentic. As Pinnegar and Hamilton (2009) argued that self-study uses qualitative research methods, the use of video- and audio-recording as qualitative data capturing methods became important for me to use in my study. My first teaching practice of one week was audio-recorded and the three weeks of my teaching practice were video-recorded. This data helped address research question 3 about learning from my teaching.

The video-recorder focused on myself, as I was the researched. This maximised the students' comfort, knowing that they do not have to be captured in the video. The video recording was done by a fellow PhD student whom I asked to be my research assistant. The reason I asked someone to video-record me instead of putting the recorder in one place was to capture all my movements in the classroom. Although using a video-recorder captures sounds, I had an audio recorder in my pocket to accurately capture my speech as I moved around the classroom. Having the audio recorder also helped me to capture the discussions that I had with students.

### 3.6.5 Students' interviews

Students' feedback can be gathered through a variety of methods. A questionnaire is one of those methods. However, questionnaires are restrictive because, sometimes, participants do not respond

to all the questions, and the researcher does not have an opportunity to question and probe the participants.

With interviews, you have full access to the information so that you can overcome poor responses from the questionnaire (Alshenqeeti, 2014). Boyce and Neale (2006) assert that interviews are designed to explore the respondents' perspectives on a particular issue. However, this depends on the kind of interview and the nature of the questions asked. For example, in-depth interviews are used to get thick descriptions. Structured interviews, on the other hand, restrict the interviewer from probing to get rich data (Alshenqeeti, 2014; Xerri, 2018). In this study, I used semi-structured interviews to gather students' feedback about my teaching to answer research question 4. I adapted the interview questions used by Nyamupangedengu and Mandikonza (2018) to collect the students' feedback. The interview schedule showing how I adapted the questions is included in Appendix A.

The extent to which interviews can yield rich data also depends on the nature of the interviews. There are individual interviews and focus group interviews (Opie, 2004). I collected data through focus-group interviews. Focus group interviews are designed to elicit people's ideas, attitudes, and experiences on a certain phenomenon (Xerri, 2018). The phenomenon, in this case, was my teaching. Using focus group interviews enabled the students to remind each other about certain incidences of my teaching. The students were interviewed two weeks after the end of my teaching. Most students gave their consent to be interviewed (39). Eventually, 11 students were interviewed. Before the interview, I asked the students to indicate their availability. I created three groups for the interviews. The number of students per group varied from three to four. The details of students who were interviewed in the focus groups are included in Appendix B. I have also included the students' other major subjects and their phase of specialisation because some of their feedback on my teaching referred to these. For example, one student felt that the lectures did not prepare her enough to teach senior primary students.

I did not interview the students myself because the students would not have been free to talk about my practice. Nyamupangedengu and Mandikonza (2018) found out that students are unlikely to voice enough descriptive details of their experiences in the course if it is the lecturer interviewing them. This is because the students would assume the lecturer would have details of what happened in the lectures. Hence, I employed an honours student who attended two of my lectures and

watched recordings of the other two lectures to conduct the interviews. The student was briefed in terms of understanding the interview questions and the skills of conducting interviews. The briefing included descriptions of my study and how the students can be probed during the interview. This increased the rigour in the data collection process. My presence during interviews would have influenced the students' responses and the extent of depth to which they respond to the questions.

### 3.6.6 Discussions with critical friends

According to Samaras and Freese (2006), self-study goes beyond personal inquiry. It is interactive and interpersonal. This means that although self-study is about the practice of one-self, it involves others and interacting with them regularly throughout the study. The others are called critical friends. Critical friends are important as they critique the researcher's interpretations and offer their input and perspectives of situations, experiences, and thoughts (Samaras, 2011). Planned meetings with my critical friends were audio-recorded. I then listened to the audio-recordings and made sense of the discussion and responded to their questions, concerns, uncertainties, and critiques. The critical friends' comments and questions are used throughout the findings reflected in the chapters to gain insights and interpret my findings. I present how I identified my critical friends and the role they played in this study below.

## 3.7 IDENTIFICATION OF AND INTERACTIONS WITH CRITICAL FRIENDS

Critical friends are important in self-study because they help the researcher to co-construct knowledge, reframe practice, and question their assumptions (Fuentealba & Russell, 2016). As such, being a critical friend requires dedication, trust, and support (Schuck & Russell, 2005). In my study, the critical friends had to do a lot of reading, watching my video-recordings and meetings. It is important to select critical friends carefully for different purposes in the study as this influences the validity of the feedback. My critical friends varied in terms of the roles that they played in my study.

I approached four people (Jane, Timmy, Celia and Edon) and asked them if they could be my critical friends. I approached Jane and Timmy because they were LS teachers. Edon and Celia

were teacher educators, and I wanted their expertise as science teacher educators. The details of these critical friends are given in Appendix C[16].

Since my study was subject-specific in that I was learning to teach biology, I needed to have critical friends who were in the field. This means some of the critical friends were *subject experts*. The subject experts also focused on issues of biology content when they gave me comments. For example, they played a huge role in validating the content knowledge that I wanted to teach to the pre-service teachers and giving me feedback which was specific to the teaching and learning of biology. For example, I gave my teaching and learning materials such as worksheets, PowerPoint slides, and assessment tasks to these critical friends. There were five of these critical friends (Audrey, Eunice, Jane, Celia, and Petronella) as indicated in Appendix C. Audrey (supervisor), Eunice (supervisor), and Celia are biology teacher educators. At the same time, Jane and Petronella are high school biology teachers.

*The role my supervisors played in this study*

In most research projects, the role of the supervisor is to guide the student in conceptualising research and providing feedback on drafts. The feedback would be about general academic writing and the contents of the draft presented, and their contribution to the final thesis is implicit. My two supervisors were more than that. In addition to their roles as supervisors, they acted as my critical friends and participants in the study. Therefore, in addition to the supervision expectations, the comments and probes that they provided to help me reflect and gain insights from my practice were incorporated into this study. In addition, Eunice played a role as a subject expert when I was planning to teach the human ear for one week. Audrey also acted as a subject expert, especially for the topic of population ecology since she has taught the topic several times and has a strong theoretical background of the topic. The two supervisors would, on several occasions, join the meetings that I had with my other critical friends.

[16] There are other people who contributed to this study in a *critical friendship* way. Some of these people are not included in the appendix. I am only including those that I have maintained throughout the study.

## 3.8 COLLABORATIVE PLATFORMS FOR PUBLIC SCRUTINY, TRUSTWORTHINESS AND VALIDATION OF MY STUDY

In self-study, how other people think about your practice is significant because the results and insights are framed around responding to their thinking and critiques (Schuk & Russell, 2005). Therefore, throughout the study, there have to be some ways of collaborating and making research available for scrutiny. Making research available for public scrutiny also assists with the validation of the study, just like any other educational research. Throughout the study, there were different platforms that I was exposed to, to make my research public and for validation purposes, as shown in Table 3.2 below. I got feedback that came in the form of questions and suggestions on these platforms. Some of this feedback is incorporated in the findings of this study and was treated in a similar way as the critical friends' feedback because it prompted my thinking and questioned my practice and assumptions about teaching a biology content course to pre-service teachers.

**Table 3-2**

**Platforms where I made this study available for public scrutiny**

| Platform | Description of the platform | What was presented/discussed? |
|---|---|---|
| Southern African Association of Research in Mathematics Science and Technology Education (SAARMSTE) | Annual conference where scholars (local and international) meet for 3-4 days and present Maths, Science and Technology Education research | January 2017 – My proposal |
| | | January 2018 – Learning about how to promote interaction in lectures |
| | | January 2019 – Insights from reflecting on my design and use of PowerPoint slides |
| | | January 2020 – Biology teacher educators' planning to teach |
| South African Educational Research Association | An annual multidisciplinary conference | October 2018 – (1) Using students' feedback to learn about teaching a biology content course to pre-service teachers<br><br>(2) My reflections on my experiences as an undergraduate student |
| Quarterly Wits PhD weekends | A meeting of all PhD and master's students to present their research | March 2017 – Proposal (formal review) |
| | | May 2018 – Literature review and conceptual framework |
| SAARMSTE Research Schools | Research schools organised for PhD students and early career researchers. | June 2017 – analysis of my teaching of the human ear |
| | | June 2018 – coding students' interviews |
| | | July 2019 – presenting the final chapter |

| | | |
|---|---|---|
| Writing retreats | The retreats organised by my supervisors, the faculty of humanities and the school of education. | Almost all the writing retreats were on analysing my data and presenting insights |

Apart from the collaborative platforms where I showcased my research, maximising validity and reliability was still needed. Researchers need to thoroughly think about the aspects of validity and reliability as they affect the quality of research findings (Golafshani, 2003). Furthermore, researchers need to think of validity and reliability in relation to data collection and analysis. Validity is defined as how the study accurately represents or reflects what it measures while reliability is the extent to which similar results can be produced in similar instances (Silverman, 2000). The concepts of validity and reliability are mainly associated with quantitative research in the positivist paradigm. In qualitative research, working within an interpretivist paradigm, validity has been replaced by accuracy and/or trustworthiness (Feldman, 2003). Some scholars like Hatch (2002) argued that terms like conformability, credibility, dependability, and transferability can be used to refer to validity and reliability in qualitative research. In self-study, trustworthiness of findings is of fundamental importance, as it is a portrayal of one's practices advanced by sharing and discussing those particular practices (e.g. a teaching practice) (LaBoskey, 2004).

I maximised the trustworthiness of the findings of this study in two main ways. First, involving "others" in the process of carrying out this study. Pinnegar and Hamilton (2009) are of the view that the voice of "others" is used to provide evidence of our claims and to ensure that "taken-for-granted" incidences are avoided. For this study, the voice of the "others" came from my critical friends and experienced teacher educators. The critical friends critiqued my practice and helped me to understand situations from different perspectives. Discussion with critical friends was a continuous process and began at the proposal stage until the writing of the thesis. Critical friends also helped me interpreting and bringing out insights from my practice.

Secondly, triangulation was used to ensure trustworthiness in this study. Triangulation is defined as the combining of two or more data collection methods consciously (Silverman, 2000). The multiple ways of gathering data in this study included observations of experienced teacher educators, interviews with pre-service teachers, discussions with critical friends, journal entries, and recordings of my actual teaching. Not only did I collect data from these sources, but one data

set would inform the other to answer one research question (see Figure 3.1). This was aided by the practices like reflection, which would draw from different data sources.

## 3.9 ETHICAL CONSIDERATIONS

Ethical considerations are crucial for every research endeavour that involves humans as participants. The issues of ethics in self-study are slightly different from those where the researcher acts as a neutral outsider. Since this research was a self-study focusing on myself as a novice teacher educator, most of what I did in collecting data involved me as the primary source of data. Additional data was collected from experienced teacher educators, critical friends, and the students that I taught. In other words, I did this research with the colleagues and the pre-service teachers. Although this was not a collaborative self-study, negotiation of meaning with the experienced teacher educators and critical friends brought in the issue of what Cuenca (2020) called "relational ethics" (p. 472). The relational ethics were resolved by formulating a common ground with the experienced teacher educators and critical friends. This involved exploring how I, as the researcher and the researcher can bring improvement to the experienced teacher educators' practice. It further involved reaching an agreement about their contribution in the study.

I did not anticipate any acts that could be harmful to the participants. Although this kind of research does not put the lives of participants at risk, their consent to participate in the study was still necessary. As such, the following steps were followed:

i. Getting ethics clearance –Wits requires every researcher to have ethics clearance before they can conduct their research. As such, ethics clearance was sought from the University of the Witwatersrand Human Ethics Research Committee (See Appendix D for the ethics clearance letter).
ii. Permission from the Head of School of Education – formal permission was sought from the Head of the Wits School of Education. I sent an email to her assistant with a letter that explained my intentions and what my study was all about. The head of school requested a meeting with me, and I was granted permission to continue with my study (See Appendix E for the signed permission from the head of school).
iii. Informed Consent – All the participants were informed of the study and how their contributions would help in the process of carrying out the study. Firstly, I requested a

meeting with individual teacher educators to discuss my study and how they would help me in the study. All the teacher educators were happy to assist me. They permitted me to observe their lectures, drop them an email about something or with questions, and to consult with them as and when I need their input. Secondly, I requested permission from the pre-service teachers who I was teaching to be audio-recorded (See Appendix F for the letter and consent form). I gave the students consent forms that stated the purpose of the study and outlined the methodological procedures that the study would follow. Although consent forms were given to 98 students, 11 of them did not consent to be audio-recorded. In the consent forms, I assured the students that participating in the study was entirely voluntary, and they may decide not to give their consent.

iv. Assurance of confidentiality and anonymity – The consent forms were accompanied by an information sheet explaining the purpose of the study. In the information sheet, the students were assured that they will remain anonymous. The names used in this study are pseudonyms (except the names of supervisors). This also applies to the names of the critical friends and the teacher educators that I observed. This excludes my supervisors (Audrey and Eunice).

## 3.10 CONCLUSION

The purpose of this chapter was to describe and discuss the design of this study. This chapter offered a description of how the study was designed and conducted. I have started this chapter by discussing how this study was qualitative. I also discussed how self-study, as a methodology used in this study, fits into qualitative research. The chapter also discussed the profiles of participants that were involved in this study and the data collection techniques that were employed. The discussion outlined how critical friends used in this study were identified. The chapter briefly described the procedures that were followed in this study to ensure the validity and trustworthiness of findings. Ethics related issues related to this study were also discussed in this chapter.

The four chapters that will follow present findings in terms of the insights gained about learning to teach biology to pre-service teachers. Each chapter or a section of a chapter begins with a description of how I made sense of the data to draw the insights. The next chapter (Chapter 4), presents insights from learning to teach biology to pre-service teachers through exploration.

# CHAPTER 4: LEARNING ABOUT TEACHING BIOLOGY TO PRE-SERVICE TEACHERS THROUGH EXPLORATION

## 4.1 INTRODUCTION

The previous chapter was about the design of the study. My PhD was a journey of exploring ways of learning how to teach biology to pre-service teachers. Exploration in this context means an act of searching for knowledge of teaching pre-service teachers. The current chapter is about learning through exploration and divided into four sections. In this chapter, I demonstrate how I learnt about teaching biology to pre-service teachers by being reflective and exploratory as a novice teacher educator. This chapter will help me partially address all my four research questions as listed below:

1. What do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?
2. How do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?
3. How does planning and teaching a biology topic help me learn to teach biology to pre-service teachers?
4. What knowledge about my teaching do I gain from student feedback?

In the first section, I present insights gained through exploring my experiences as an undergraduate student. The second section is about learning from observing other biology teacher educators' lectures. The third section is about learning from planning and teaching a biology topic for one week. In each of these sections, I first provide a short description of how I drew insights from the data and end the section by giving a summary of what was learnt and how the learning occurred. I then conclude the chapter by providing concluding remarks.

## 4.2 REFLECTING ON EXPERIENCES AS AN UNDERGRADUATE STUDENT

In this section, I present how I learnt about teaching biology to pre-service teachers by reflecting on my experiences as an undergraduate student. These experiences played a major role in my perceptions about teaching biology and influenced how I learnt to plan and teach. In subsequent sections of this chapter and Chapters 5 and 6, I refer back to these insights and articulate my new

understanding, challenges, and dilemmas about learning to teach and teaching biology to pre-service teachers.

### 4.2.1 Procedure used for drawing insights

Data for learning from reflecting on experiences was embedded in the journal entries that contained my experiences. To make sense of the journal entries, I firstly narrated my experiences in detail. The narratives contained my initial reflections on the experiences. Secondly, I reflected further on these narratives where I questioned my thinking of when I was a student versus now as a novice biology teacher educator. Thirdly, I presented my narration of experiences and my reflections to the critical friends. My critical friends would give me feedback in writing, or we would meet and discuss the feedback. The last step was to respond to the feedback coming from the critical friends by reflecting further and bringing out insights for learning. Therefore, my critical friends' comments and questions helped me to draw insights from these experiences. In some cases, before drawing insights, I present an account of an interaction with a friend.

### 4.2.2 Lessons from reflecting on how lectures were presented in my undergraduate studies

When I was a student, I was exposed to a variety of teacher educators with different expertise and ways of teaching. Most of the teacher educators read notes on their PowerPoint presentations during lectures. However, some teacher educators strived for student participation by asking questions at the beginning of lectures. Since I had been exposed to many of those who read from the slides, I had a belief that reading PowerPoint slides was an acceptable way of teaching at the university level. Although these teacher educators asked questions in the lectures, the questions were in patches, and the lecturer would just confirm or refute an answer from a student. I then lost interest in the subject such that I shifted my focus to passing and getting my qualification. Their practice of reading slides also made me stop attending lectures.

A few days before my one-week of teaching, while discussing how I wanted to approach my first lecture, I presented this narrative to Eunice. She had already seen my draft of PowerPoint slides for my first lecture. She asked: *"*What do you think was missing?" and if I still had the same perceptions about those teacher educators. My response was that I was denied the opportunities to make sense of the content. It was the lack of engagement that demotivated me and made me lose

interest in attending the lessons. My thinking was that the teacher educators could not interact with us or provide us with opportunities to interact with each other or the content itself because they constructed their PowerPoint presentation in such a way that it was populated with text.

**My reflection and lesson learnt:** From reflecting on my experiences, I learnt that teaching that is based on meaningful engagement with content has the potential to motivate students because I have now realised that if I was engaged, I would have been motivated to learn and attend lectures. It would have aroused my interest in the subject as well. However, now as a novice teacher educator, my thinking is that lack of meaningful engagement cannot only be attributed to the practice of teacher educators populating slides with text. This helped me remember that there were some teacher educators who taught science without PowerPoint slides but still could not provide us with the opportunities to interact. As much as the construction of slides could have been a factor, there could have been other reasons like the nature of the topic they were teaching or even the teacher educators' teaching objectives. The realisation that I lacked meaningful engagement propelled me to begin thinking of a variety of ways (including how I construct my slides) in which my students can interact for meaning-making of the content I am teaching and ways in which I can motivate students to attend lectures and learn.

### 4.2.3 Lessons learnt from the use of questions by teacher educators at the beginning of and/or during lectures

I have indicated in the previous experience that some teacher educators asked questions, especially at the beginning of the lectures and in some cases, as the lecture continued. In many cases, they would ask us to talk about what we knew about the topic or concept they were covering. As they asked a question before introducing the topic, we participated a bit and learnt from each other. In one instance, the teacher educator was teaching about the biochemistry of respiration, and she gave us a short activity with true or false questions that she requested us to submit and revisited the activity in the second lecture. On another occasion, we were given a short activity that tested our knowledge of genetics terms. I saw the significance of these questions and small activities given to us at the beginning of the lecture when the lecturer clarified why our answers were incorrect. For example, I remember using the terms respiration, gaseous exchange and breathing synonymously and the lecturer clarified how they were different.

**My reflection and lessons learnt*:*** The purpose of these questions and activities was to seek our prior knowledge and detect our misconceptions. I appreciated those teacher educators because their approach helped me as a student even if it was clarifying one minor confusion. As a teacher educator, I now have realised the importance of always seeking to understand students' prior knowledge. When prior knowledge was sought verbally, there was never a moment where everyone would keep quiet. There was always someone who tried to answer the question. This helped us connect the concepts. From this experience, I have learnt how small activities or questions at the beginning of a lecture can be used to get students' prior knowledge and be a powerful resource to inform my teaching as a biology teacher educator.

### 4.2.4 Lessons learnt from my interaction with my university mentor during the teaching experience

I revisited my experiences explained in Chapter 1 Section 1.3.2 about my teacher educator as a mentor during my teaching practice in schools. My teacher educator indicated that I needed to find better ways of teaching the circulatory system. She specifically indicated that I could find useful ideas about how to teach well from the internet, as there are numerous videos that one can watch on how to teach specific topics. Although I found her suggestion useful and relevant, it was also surprising for me because it made me question the significance of attending lessons in the institution if I still could not teach better. I did not understand how I can be referred to a resource while the teacher educators themselves did not *show* me how to do certain things like using concrete materials and logical explanations. I thought that it was their duty always to show us how to teach biology topics.

Eunice asked me; "How was it their duty to teach you how to teach? Do you still see that as important now?" I felt like they were not fair because I cannot be expected to apply the theory that they gave me during lessons without *having seen* how it is done. My thinking has now changed because of how I see things from a teacher educators' perspective.

**My reflection and lessons learnt:** It is important that the teacher educator must teach pre-service teachers how to teach. Also, it is my duty as a teacher educator to try and model some biology teaching approaches for my pre-service teachers (Lunenberg et al., 2007). However, modelling would be about the approaches of teaching biology in general (and maybe some topics in a broader sense) and not how to teach a particular concept to particular learners in a specific context. In

addition to modelling practice, the pre-service teachers can be equipped with skills on how they can think of teaching biology in their contexts of teaching. It is better to give the students the skill of using some of modelled practice in lectures and theory as a *model* or a basis to think of how they can teach other biology topics in their contexts of teaching. Hence the idea of modelling teaching practices by linking exemplary behaviour and theory as well as facilitating the translation to the pre-service teachers' practice is important to me as a biology teacher educator (Lunenberg et al., 2007). Just like Nyamupangedengu (2016) who demonstrated that modelling is a valuable approach in teach content course to pre-service teachers, I have come to realise that I also need to model practice to my pre-service teachers.

### 4.2.5 Lessons learnt from how tutorials were done and questioning in the tutorial activities

When I was a student, the lecturers used to give us tutorial questions before the tutorial sessions, and the answers would be marked for summative assessment purposes. Although the idea was for us to engage with the content and questions before the actual tutorial session, it seemed not to be working. This is because we focused more on getting the right answers rather than engaging with the course content. I got most of the answers from the internet without making sense of the questions and the responses I gave.

Eunice commented on this experience and asked if using the internet was a bad practice. Taking into account the usefulness of the information that one can get on the internet, it is not a bad practice. We were encouraged to research, and the internet was an accessible and most comfortable source of research. The issue was with the questions and not how these tutorials were run. Many of the questions were multiple-choice or required short answers and a lot of these questions were taken from the internet. As a student, I realised this when using the internet as a resource.

**My reflection and lessons learnt:** The practice of giving students tutorial activities beforehand works and could be good practice for me as a biology teacher educator. However, this depends on how the questions are constructed in the tutorial activities. Now, as a teacher educator, it is important to construct and administer tutorial tasks that trigger discussion and interaction among students for effective learning to take place. This can be done by constructing questions that require students to produce descriptive and interpretive responses that would guide and propel a student to take part in the practical session. These questions may include those that are coming from the

discussions in the lecture such that they offer the students opportunities to make links to what was covered (Cocoletzi Vásquez, Ivonne Ramos-Robles, & Morales-Linares, 2018).

### 4.2.6 Lessons learnt from participating in group work in laboratory sessions

When we were doing NS I, the first practical exercise was about microscopes, and the aim was to help us understand how microscopes work. I had no idea how a microscope looked like in real life. I had seen it as a picture only. Hence, it was important for us to go through a practical lesson on the topic. During the practical lesson, we worked in groups of three or four. This arrangement made it mandatory for me to work with *people I did not know*. At first, I was hesitant to work with other people but gradually started to participate. I learnt how to use a microscope from my peers who had some previous experience of using a microscope. The practice of grouping us during laboratory sessions was abandoned as I got to third and fourth years of my study. We would either work individually or in pairs.

Jane commented in one of our conversations: "I would want to know why they stopped putting you into groups*"* and her comment prompted for me that there could be many reasons involved in the practice of putting us in groups. Although from reflections, I had an idea of what this meant for me in terms of teaching, I asked the technician and one teacher educator, why they grouped students in laboratory sessions. The technician's response was skewed as he said it is due to the number of students in the early years of studies but still mentioned how the students are still new in the university. The teacher educator's response, above the issue of large numbers of students, was based on how students would benefit from working in small groups.

**My reflection and lessons learnt:** The main lesson that would impact my pedagogical decisions I drew from this experience was that the teacher educators' decision to group us worked because she knew that some of her students that had not seen the microscope before were going to learn from their peers. This is the kind of knowledge of context that I needed to have as a biology teacher educator – understanding that my students come from different backgrounds and they can gain from their peers as they work in small groups. The students' background includes the kind of schools to which they went (Nyamupangendengu, 2016). However, students cannot discover for themselves why they need to work in small groups, especially in laboratories (as it took time for me to get the purpose of grouping us). Making it explicit to students that the idea is for them to

assist each other would be appropriate to ease students' minds. Even those students who are hesitant to work in small groups can learn that grouping them is for their benefit.

### 4.2.7 The significance of reflecting on one's own experiences as a student for learning how to teach

In this section, I narrated my experiences and the lessons learnt from reflecting on these experiences as an undergraduate student with the assistance of critical friends. Reflecting on our experiences may be difficult as the experiences are things of the past and deeply rooted in our memories, but it offers a multi-dimensional and comprehensive approach to learning about practice (Mitchell & Pithouse-Morgan, 2014; Morrison, 1996). Some of these experiences were pleasant, and some were unpleasant, but they all played a major role in defining my practice. For example, my teacher educators reading slides was an unpleasant experience. Being grouped in laboratory activities to work together was a pleasant experience as it yielded positive results. According to Jarvis (2006), learning is embedded in reflecting on such experiences. When one is teaching the pre-service teachers for the first time, reflection on these experiences should become an integral part and should precede the actual planning and teaching. Not only do these experiences give a novice teacher educator a platform to start working from but they also provide a *clean, paved slate* for the rooting of the pedagogies to be discovered in the process of becoming and being a teacher educator. That is, what is learnt would not be rooted in the unexamined theories, perceptions, and attitudes that could negatively impact how and what one learns. Hence, learning starts from reflecting on past experiences because experiences (as raw as they are) are meaningless and offer no learning opportunities except a memory. It is only through interrogation that we see the value of these experiences.

Reflecting on the experiences that have been buried in memory is the idea of *returning* (Spiteri, 2010). Like myself, most self-study scholars have returned to their previous experiences to learn about teaching. For example, McDonough (2017) returned to her school teaching days to explore the tensions that she experienced when teaching pre-service teachers. She confirms that through reflecting on the experiences that caused tension, she was able to understand her practice better. In my case, reflecting on my experiences helped me view some of the teacher educators' practices and my practice as a student from the perspective of a biology teacher educator. In other words,

the reflections shifted my *student-based* to *teacher educator based* thinking. I now saw some of these experiences from the opposite perspective of how I would have seen them as a student.

According to McDonough (2017) and Peercy (2014), teacher educators who return to their experiences stand a chance of becoming practitioners who are cognisant of their practice. This is because, as one reflects on the experiences, the thinking that goes in involves the past, the present, and the future. Reflections on these experiences have helped me to think of "what could this mean for me when I start teaching", and this formed a significant foundation for planning to teach a biology course. Through my reflection of these experiences, I was able to retrieve information that helped me to learn about the practice of teaching biology to pre-service teachers and engage in abstract conceptualisation. Hence, Kolb (1984) and Larsen, London and Emke (2016) said reflection and experiences are the core of learning about a practice that could lead to successful experimentation of practice.

## 4.3 INSIGHTS FROM OBSERVATIONS OF EXPERIENCED TEACHER EDUCATORS' LECTURES

In the previous section of the chapter, I have presented the insights gained from exploring and reflecting on my experiences as an undergraduate student. In this section, I present the insights from observing experienced biology teacher educators' lectures.

### 4.3.1 Procedure used for drawing insights

I went into the experienced teacher educators' classrooms to gain insights into effective ways of teaching biology to pre-service teachers. During the observation sessions, I neither focused on specific practices nor evaluated the teacher educators. I took notes during the observations as described in Section 3.4 of Chapter 3. I then used those notes to produce narratives accounting for my observations which also included my reflections. In some cases, after observations, I had small discussions with the teacher educator. The discussions happened when I wanted to ask about the approach that they took when teaching that I observed. Some of the narratives were embedded in the journal entries. The narratives were treated the same way as those that emerged from my experiences as an undergraduate student, as presented in previous Section 4.2.1. The difference from those narratives in the previous section and these was that even though the narratives were exposed to critical friends, there was little involvement of the critical friends since the focus was

on what I learnt from what I observed in the teacher educators' lectures. Instead, the critical friends helped me to confirm or refute my interpretation of what I had observed in the lectures as reflected in the narratives. Therefore, in most of what I present below, I narrate my observations (including my interpretations) and the insights that I draw about teaching biology to pre-service teachers from these observations.

### 4.3.2 Negotiating assessment with students

**My narrative:** One of the remarkable things that happened in my observations was the negotiation of assessment dates with students in one of Gracious' lectures. Gracious negotiated the date of assessment with students by asking them if the date that she chose for the test was suitable for all the students. This was, as she explained to the students; because some students came to her and complained that they had two more tests for other courses in the same week and they were afraid of failing. As she was explaining, one student said: "*I have not been doing well in this course…so, I really need to get good marks in this test so that I can pass the course*". Gracious took into consideration the students' grievances about the test date because she thought about what the two students told her before the lesson and concluded that she would first discuss it with the rest of the group.

I asked myself some questions and shared with one of my critical friends, which then became the catalyst for the lessons that I learnt. The main question that I asked myself was: Why should the teacher educator discuss the test date with students? Is it not the teacher educator's duty to "dictate" the dates to students based on her teaching plan, like they did when I was an undergraduate student? To what extent can I, as the teacher educator, discuss the assessment dates with students?

**My reflection and insights:** What seemed to emerge from the observation is the issue of care, empathy and that showing interest by listening to students is important in teacher education because it affects how students learn and feel at ease in the learning space. Research shows that when students feel supported in their academic work, they tend to engage more in what they do (McCombs, 2001; Newman, 2002). The support can come in many forms, including showing some appreciation of students' contributions. An important aspect of teaching to be noted is that as a teacher educator I am teaching content *to* the people. This means teaching should be foregrounded by the concept of humanity such that in all that I do, I must demonstrate care to those that we teach.

Nodding (1992), for example, emphasises that care is the cornerstone of all educational activities. Some of the indicators of caring include responding to students' questions, listening to their grievances, helping them learn, etc. Despite this, showing students that you care is complex as it requires a balance of both the teacher and students' academic and social being (Walker & Gleaves, 2015).

Apart from negotiating the test dates with students as a sign of care and empathy, there is a lot more that students can learn from a biology class. One of the questions that I grappled with around the area of assessment was: What else could the teacher educator discuss with students that can help the students learn*?* If, for example, students are asked to write an essay on the impact of population increase on the environment, the teacher educator can discuss the assessment criteria and the marking rubric with the students in addition to negotiating the submission date. Students will not only be learning about how they need to tackle the assessment to pass but also the kind of things that need to be considered when designing a rubric. This way, students take ownership of their learning and get involved in the decision making of their assessments. Thus, the care that was demonstrated in negotiating assessment schedules gets extended to the development of the students' professional knowledge in that they learn how to construct rubrics for certain assessment tasks.

### 4.3.3 Gaining the knowledge of students and context by asking students to outline their expectations from the teacher educator and the course

**My narrative:** In the first lesson, Mariam asked students to take a piece of paper and write down their expectations in the course and from her as a teacher educator just after outlining what she expects from the students. Some of the things outlined by Mariam, as expectations, included punctuality and respect towards each other. She also emphasised the importance of class participation. She then talked about the issue of the language of teaching and learning, particularly the fact that English is her second language and that students should not focus on how she pronounces words but the concepts that she will teach and how she teaches. Mariam then asked students to put their expectations in writing and to submit them to her. In the next lesson that followed, Mariam started with a discussion on the expectations that the students had submitted to her. When giving the feedback to the students, she focused on common things, e.g. the students expecting her just to teach them what they needed to pass that students wrote. Mariam responded

that her teaching was about helping them to become better people and go out there and teach LS effectively. Another expectation indicated by the students was that "do not ask me anything when my hand is not up". Her response was that silence does not mean that they know nothing, and this was a key point for me. She emphasised the value of discussions in class. It is through these discussions that the teacher educator can give feedback to the students.

**My reflection and insights*:*** The fact that Mariam asked students to write their expectations about her and the course itself shows that teaching is not only about the teacher and what she needs to "transfer" to the students, but it is also primarily about the students. This means that everything that a teacher educator does must be in the best interest of students' learning. A teacher educator who believes that what she says goes would have just outlined her expectations to students without trying to get a sense of the kind of students he or she was teaching. This observation session showed the value of joint activity in the process of teaching and learning such that the students should take part in decision making, especially on issues that have an impact on their learning process. From this observation, I learnt that asking students to write their expectations can be a good strategy to get a sense of the kind of students I am to teach. It is a well-known fact that when teaching science, the knowledge of students is important for a teacher to know when teaching (Park & Oliver, 2008). However, it is difficult to get such knowledge before interacting with them. The knowledge of students that can be gained from written students' expectations includes how they learn or would like to learn, their aspirations, their fears and what they value most in the classroom. Likewise, one of the main findings of Sander, Stevenson, King and Coates's (2000) study is that students prefer discussion methods of teaching more than teaching that is characterised by direct transmission of information. Knowing students influences the pedagogical decisions and the kind of teaching approaches that one would use in the classroom. From Mariam's experience, it is clear that the students are wary of interaction in the classroom and what they want is just to do the work and pass. It is, therefore, critical to create opportunities for interaction in class. Although I can learn a lot about my students from their written expectations, I should, through discussions with them, make sure their expectations are aligned to those of the course as a whole.

### 4.3.4 Asking questions that propel students to *reflect* on what they learn, how they learn and the purpose of learning biology content

**My narrative:** John was teaching the topic of environmental studies to third year biology pre-service teachers. In the first lecture, John started his lesson by asking the question: "Why environment and development?" After a short discussion, he further posed the question: "Why are we here? Why do we learn all these?" (Referring to the knowledge of environmental studies). Students gave a variety of answers including that it is because they have to teach it in schools. John then responded by saying that environmental studies are a part of LS even if it is not about physiology or anatomy. Leila also used phrases like "stop for a moment and think about that as a teacher" in all her lessons. During her first lesson, for example, she asked the question "Stop and think about why we learn evolution," and "Do these points raise questions?" She asked students to read silently from the PowerPoint slides, some of which provided the reasons why students were learning about evolution. This caught the students' attention. She then asked students to free-write why teaching evolution is controversial and if it is controversial for them or their learners. She indicated to the students that she wouldn't ask them to read out what they had written, but she would ask them to refer to their notes as the course continues. She asked students to refer to their piece of writing in her subsequent lesson by asking the question: "How would you change what you have written based on what we have done so far?" I made similar observations in Leila's third lecture and John's second lecture.

After the third lecture, I asked Leila why she kept asking those questions in her lectures instead of just teaching the content of evolution as it is. She responded that it makes no difference for the students to learn the facts without understanding why they are learning those facts. In her words, she said: "I want them to get into another mental state to discover their purpose of being here and sometimes it requires reminding them of their schooling". Our discussion and these observations were a catalyst for the lessons learnt presented below.

**My reflection and insights:** Asking student questions such as the ones described above can serve the purpose of shifting the pre-service teachers' thinking beyond just being students at a university. The question of *"Why do we learn this?"* can encourage the students to think of their purpose of being in the lecture and learning that content. Therefore, not only can these kinds of questions ascertain students' learning of content itself but also the knowledge for teaching. It seems that the

questions asked further require the students to get into their identities of being students, teachers and being individuals of the broader society. These identities are important for a biology teacher educator to be aware of when teaching (Nyamupangedengu & Mandikonza, 2018) and are also important for the pre-service teachers to learn the content with a purpose. The specification that evolution is controversial for them as students or for their learners followed by a question asked by Leila about why evolution is controversial could help the students to not only think of themselves as students but also as teachers. The question by John *"Why environment and development?"* would trigger students' thinking about the application of the content they are learning and its purpose in their real lives. Hence, this kind of student thinking helps them to transition from one identity to the other in a biology content course as they learn the content of biology and also learn about teaching without abandoning their "being" as individuals who are part of the broader society.

### 4.3.5 Randomly picking students works when no one wants to answer

**My narrative:** Although there was some form of interaction in all the teacher educators' classrooms, there were instances where students would keep quiet until one was randomly picked. I have observed that Gracious and Leila randomly choose students to answer their questions as a strategy to break the silence in the classroom. The difference between Gracious and Leila's way of doing this was on the kind of questions they asked. Gracious asked factual questions like "What is the function of a plasma membrane?" while Leila asked more open questions like "What do you think happened over these million years to get the kind of animals we have now?". Randomly picking students to say something seemed to be an effective strategy for them to encourage the students to participate in class because the students answered the questions asked even though some were hesitant at first. In Gracious' lectures, although the students answered, most of the responses they gave showed misconceptions which she clarified. For example, when she asked what makes up the cytoplasm of a cell, she randomly picked a student who answered that it is the semi-liquid jelly distributed between the organelles. In contrast, Leila seemed to be randomly picking students when she was asking open-ended questions for students to voice their ideas

**My reflection and insights*:*** Randomly picking students to answer questions works, firstly, because one can address misconceptions and errors that the students have – even if they are minor errors. The response that the student gave in Leila's lecture had a misconception that the cytoplasm

is only made up of a semi-liquid jelly whereas it has a skeleton. I thought that if students are silent, they do not know the answer. However, my observations helped me realise that student silence does not mean that they are not thinking but could mean that their thinking is fragmented and has some misconceptions. Asking them factual questions would help reveal their misconception while open-ended questions would help reveal their opinions. I realised that this could be a good strategy to keep students on their toes. Furthermore, even if they refused to answer, it would be a starting point for them to think about the question and an alert for others that they need to have something to say if they were picked. I kept this strategy in mind for use during my teaching when students keep quiet.

### 4.3.6 The significance of learning from observing experienced teacher educators' lectures

In this section, I presented insights gained through exploration by observing experienced biology teacher educators' lectures. I neither focused on specific aspects of practice nor evaluated the teacher educators when I was observing. Although I saw similar practices in the teacher educators' lectures, the practices were undertaken in different ways and revealed different results. For example, the approach of randomly picking students to answer a question was used by Gracious when she asked factual questions and Leila when she asked more open-ended questions and helped Gracious to address misconceptions. This could be because of the teacher educators' expertise and it could also be about the nature of the topics and the kind of students that the teacher educators were teaching. This is an important insight for me – I should not assume that certain teaching approaches will work in every context in which I am teaching. Hence understanding context first is important.

The lessons indicated in this section are an indication that a novice teacher educator can learn by observing experienced teacher educators. It is not only the observations that enabled me to learn but also the informal discussions that I had with some of the teacher educators after observations especially asking them why they do certain things in the lectures. These small discussions helped me to reflect and bring in my experiences from when I was still a student to draw insights. I grounded myself in the discourse of professionals that were using the same techniques on me (experienced teacher educators). Feiman-Nemster (2001) indicated that learning in those discourses takes place through conversations that create a culture of inquiry and support. The

observations elevated my inquiry and stimulated the need to take a challenge of how I can use what I have gained in my teaching practice. It, therefore, became important to me to practice what I have learnt and gain more insights about teaching biology to pre-service teachers.

## 4.4 TESTING THE WATERS: EXPLORATION OF MY TEACHING THROUGH PLANNING AND TEACHING FOR ONE WEEK

As indicated earlier, my planning and teaching were influenced by my previous experiences and some of the lessons I learnt from experienced teacher educators' lessons, as presented in Section 4.3 above. In this section, I present the insights and lessons learnt after teaching the topic of the human ear. I also use the students' written feedback to support the lessons learnt. The insights presented here include the challenges and new understandings and dilemmas that I encountered in my one-week teaching duration.

### 4.4.1 Procedure used for drawing insights

Data for this section came from my one-week teaching of the topic of the human ear and the students' written feedback on my teaching. I was allocated the one week of teaching because I had been observing the teacher educator (Eunice) who was teaching the course at that time and was also involved as a tutor in tutorial sessions. I invited Eunice to come and observe my teaching. The one-week teaching was a double lecture and a single lecture. Although the lectures were audio-recorded, I sat down after every lecture to generate narratives of what happened and my initial reflections. Excerpts from my teaching are used in some cases to support my narratives. My narratives included my interpretation of the written feedback I got from students. Hence, I quote what students said and use that as a lens and evidence to support my narratives. I used Eunice and other critical friends' comments to draw insights from the narratives.

### 4.4.2 Effect of complex biology terminology inhibiting clarity of explanations and students' understanding of the content

In the second lecture, I was teaching how the ear detects and transmits sounds for a person to hear. I had just finished explaining the structure of the middle ear and started with explaining the inner ear (cochlear). After a long explanation, as shown in the excerpt below, I got an unexpected response from students.

**(1) Lecturer:** *So, if we cut through the cochlea, we find this… and inside, if we can look at the uncoiled cochlea, at the roof, we have what we call the vestibular canal, at the floor, we have what we call the tympanic canal, and in between the two canals, we have what we call the cochlea duct, and at the floor of the cochlea duct, we have the organ of Corti. So, it is in that organ of Corti that we find the basilar membrane and the hair cells with kinocilium, which are the receptors of hearing.*
(I was continually pointing at different parts of the picture on the screen using a laser pointer)

**(2) Students:** *Yoh!!Aiiii….ahhhhh! (Noise from students)*

**(3) Lecturer:** *Do you understand this?*

**(4) Students:** *No!...Aiii... we don't.*

When I was observing the teacher educators, I did not pay attention to how they handled the biology terminology. The excerpt above was an important episode during my learning process because it challenged my thinking about effective ways of teaching biology concepts to students, specifically looking at the use of terminology and explanations for clarity. The following student written feedback assisted me in learning from the episode.

**Student 9:** *You introduced a lot of concepts without explaining them. Therefore, this led to my confusion. Please try to explain deeper or give definitions to the biology terms*

**Student 11:** *Too much content and too many terms that you did not explain in detail*

I had to think of the pedagogical implications of terminology as reflected in the students' written feedback on my teaching of the human ear. In addition to what the students said, Eunice commented on my use of terminology that she had realised from my first lecture, "*The students know about the bones in the terms they used in schools. Why not use that instead of going straight into what they hear for the first time?"*. As a starting point in learning these strategies, Eunice made me aware that some biology terms have simplified versions that can be used and that I can use those to ease the learning of students. Her comment and the pre-service teachers made me think of what I believed to be effective when teaching biology to pre-service teachers.

**My reflection and lessons learnt:** Although I knew that terminology is one of the factors that affect teaching and learning of biology, I thought that nothing could be done since the terminology is what makes the biology content. Thus, terminology cannot be avoided in any way. The students just have to master it! I did not realise how this would affect the clarity of my explanations and

coherence and logic in their learning. It is evident from this extract that the lack of paying attention to how I use the biology terminology has been one of the major factors that affect my teaching not only in the first lecture but also in the second lecture. Confusion arises if technical terms are not explained during a lecture, and this compromises meaning-making (Zukswert, Barker & McDonnell, 2019). For students to have a meaningful and conceptual understanding of biology content and how concepts are interrelated, they need to understand how the structure suits the function for most biology topics (Cohen, 2014). However, to understand the relationship between structure and function, they also need to understand the terminology that is involved. Therefore, understanding the terminology is likely to lead to understanding the content itself and how concepts are related to each other to attain holistic understanding.

I held the assumption that biology has its own terminology that makes up the content knowledge and should be communicated and taught as such; in its language. This thinking gradually changed as I reflected on my teaching. Students are still likely to understand the biological concepts when the terminology is defined early enough during the lecture (as requested by student 9). Zukswert et al. (2019) believe that biology terminology should be explained in context to develop students' biological literacy. I lacked the knowledge of pedagogy that could help me simplify the *big* biology terms. Not only did I lack the strong pedagogical knowledge in terms of the strategies for dealing with the biology terminology, but I also did not have a robust understanding of content knowledge to be able to make sense of the whole topic in a holistic manner, leading to my inability to deal with the biology terminology. What is important here is the use of the term without losing the meaning of the content taught. Assuming I have strong content knowledge, this became a motivation for basing my second round of observation on how experienced teacher educators deal with the biology terminology.

### 4.4.3 Structuring PowerPoint presentation for interaction, coherence and giving good explanations

As indicated in insights drawn from my experiences presented in Section 4.2.2 that the structure of PowerPoint presentation as an instructional material can affect how interaction takes place in class, in my planning, I was trying to find ways in which I can construct the slides for interaction. I attempted to do this more than once, and with the help of critical friends in the process, I

continuously gained insights. Before that, I reflected on the question: "Why do I want to use PowerPoint slides is it necessary to use the slides?" I had the following aims:

1. I want all of my students to attend my lectures
2. I want my students to see visuals – biology structures
3. I want to engage my students both cognitively and socially

In ***my first attempt*** (preparing for the first lecture), I had a visual in one slide and text next to the visual. I planned to show students the visual and align my explanations with the text presented. I also wanted to use the visual as the basis for asking questions. After presenting the PowerPoint presentation to my critical friends, I discussed with Nelly:

**Nelly:** *What will you be doing with students when you display this slide?* [The slide had the structure of the ear with explanations below]
**Myself:** *I want to interact with them…sort of asking questions as I explain the structure.*
**Nelly:** *I don't know what you will ask them, but the explanation at the bottom tells about the picture.*

**My reflection and lessons learnt:** Nelly's question intrigued me because she said: "with students". This gave me a signal that in preparing the slides, I need to think of students and ask myself the question, "What am I doing with each slide on my PowerPoint?" Answers to the questions that I would ask were captured in the explanation at the bottom of the slide. Thus, I learnt that having a diagram and text in one slide would not work if I want the students to interact with the diagram. Brock, Joglekar and Cohen (2011) assert that instructors need to ask themselves the question for whose benefit the slides are. This is what directs the order of slides and the amount of time invested in preparing these slides. Therefore, the insight that I gain from Brock et al. (2011) and Nelly about preparing PowerPoint presentations is that I need to understand for whom the slides are prepared for (students, lecturer or both) and the purpose (e.g. for students to copy the notes) of preparing the slides. Now, I know that the text on the slides must be minimised to encourage students to attend lectures and take notes based on my explanations or based on the discussions that ensue during lectures. But is that part of participation? I think it is because students need to take notes from my explanations, and taking notes involves writing down their

understanding of what I would have said which would mean they would have cognitively engaged with my explanations.

In ***my second attempt,*** I separated the text from visuals; which is the design that I ultimately adopted in my lectures during the one-week teaching. I planned to engage students using the visual by asking questions and presenting some minimal text on the slide to explain the visual and key points emerging from the class discussion. The diagram that was on the slide is given in Figure 4.1 below.

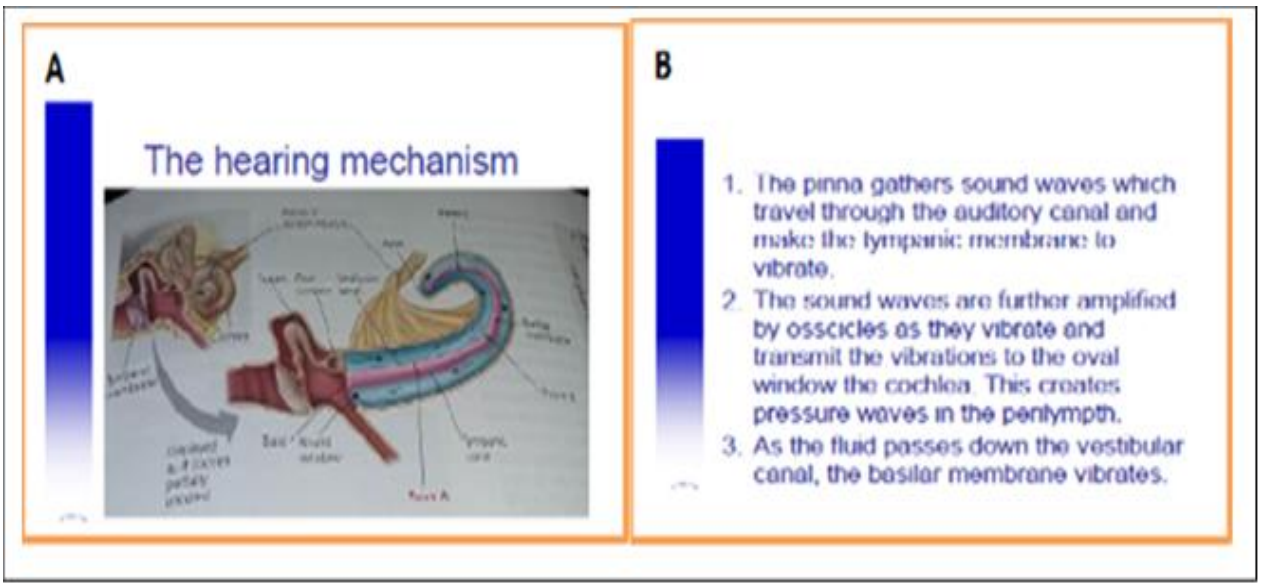



**Figure 4.1 The structure of my PowerPoint presentations when teaching the topic of the human ear**

After teaching the first lecture, I found that particular sequence of slides in figure 4.1 to be an effective way just to catch students' attention. It was, however, difficult to retain that attention and for the students to engage with the diagram shown. In Section 4.2.2 of this chapter, I have indicated how I lost interest in the subject because of teachers who read their PowerPoint slides without accompanying explanations. Instead of following the practice of some of the teacher educators who taught me, that is, reading PowerPoint slides without explanations, I have minimised reading and resorted more to explaining the slide content. Although I did not read the slides and engaged students, this seemed not to be working for coherence purposes as reflected in the students' feedback below.

> **Student 23:** *Sometimes I got confused because you were ahead of your slides like saying things that are in the slides to come. Now I had to do back and forth on my handout.*

**Student 2:** *You gave a lot of explanation that would cover everything, and towards the end, it was more of repetition of everything*

Students 2 and 23 were confused by how I navigated through the slides and my verbal explanations during lectures. I constructed the slides in the order that starts with the pictures or diagrams and then explain the content, but my aim of engaging the students both socially and cognitively (aim (3) indicated above) was not fulfilled.

**My reflection and lessons learnt:** After engaging with the insights that I gained from my conversation with students, I realised that a straight forward movement from slide A to B would not engage students in a way that I envisaged. I noticed that the level of interaction with the visual decreased in the second lecture. Students would know that text with information will follow after every visual. I was then faced with a dilemma of removing the texts completely and just teach with the visuals. The following questions became a catalyst in making such a decision.

1. What idea am I teaching? (I am teaching the idea that the ear is responsible for the rotational movement of the body.)
2. How best is this idea classified (as a structure and function; or the process or mechanisms)? (It is both structure and function and process but I want to teach the mechanism of rotational movement.)
3. What do I want students to know and take away in this teaching episode? (At this point, I want them to know and understand a series of steps or events that take place for the ear to detect the rotational movement of the head and not necessarily the structure and function relationship of what is involved in the mechanism.)
4. What can be used to best explain a series of events? (A flow diagram [the only tool I could think of at that time] that shows how each event follows from the other to make a complete process.)

I found the four questions helpful in making pedagogical decisions when teaching a biology idea. These four questions may be used during planning so that the fourth question can be well considered and the reasoning for the action anticipated during instruction. I kept this thinking to inform my planning of the teaching of population ecology, which then developed my learning and understanding of using PowerPoint presentation as instructional materials in teaching biology (see Chapter 6).

### 4.4.4 What happens when students do not have prior knowledge as a basis for meaningful engagement with the content?

In the middle of my first lecture, I wanted to engage students using their prior knowledge in my teaching. I asked students a question about how ossicles are suited to their function. The question required students to think about the structural differences of the malleus/hammer (first ossicle) and stapes/stirrup (third ossicle) in relation to their function. None of the students attempted to answer the question even after I provided hints and probes. The students' silence for more than five seconds had me thinking about the question that I asked them and how I phrased it. I expected them to be able to answer the question because they did the topic of the human ear in Grade 12. Feedback from student no 6 on my teaching made me question my understanding of what prior knowledge is.

> **Student 6** *To be honest bro, yes I admit that I come late but what I noticed about you is that firstly, you assume that everybody has got an answer to your questions about the ear while you are to teach it (how do you expect students to know what you are currently teaching already?)*

**My reflection and lessons learnt:** I have learnt throughout the years as a student and from literature such as Glogger-Frey et al. (2018) and Hailikari, Katajavuori and Lindblom-Ylanne (2008) that as a teacher you need to get students' prior knowledge to detect their misconceptions and for interaction purposes. However, I found myself in a position where the students seemed to have no prior knowledge. I always asked myself the question: Did the students' silence show that they had no preconceived ideas about the question that I asked? I noticed that I held certain assumptions about students and knowledge. I assumed that students always had prior knowledge about a concept and disregarded the fact that that they actually may have forgotten the content since they covered the topic three to four years ago in their matric studies. In addition, some may not have done the topic at all depending on the syllabus they followed by the time they matriculated. It is important to note that the question was a conceptual question that required students to have conceptual knowledge about the structure of the ear and account for structural differences of different parts of the ear. Hence, the prior knowledge that I thought they would have should have been the knowledge that was formally taught to them. The students will not always have prior knowledge for certain concepts as expected. Furthermore, it also depends on the kind of question asked, as Jane commented:

**Jane:** *The type of question we ask like what do you know about the ear…it almost feels natural for me to say something but when start…becoming conceptual, the confidence of the students comes down. Then you use your pedagogical strategies to think about how you could have said 'tell the person sitting next to you like to validate their thoughts*

**My reflection and lessons learnt*:*** Jane helped me realise that for students to speak and expose what they know (prior knowledge), sometimes depended on whether the question was conceptual or open-ended. For conceptual questions that require a certain level of understanding of the content, strategies that require students to think and process their thinking are needed. An example of such strategies would be allowing the students first to discuss the question in small groups. Simple questions like *"What do you know about this?"* are indeed questions for students to explore and for the biology teacher educator to move the students to the new biology content. In other words, open-ended questions open up opportunities for students to speak, and, in most cases, a variety of responses will be elicited (Chin, 2007). The question that I asked required students to use the science vocabulary and make connections between concepts. Chin categorised such questioning approaches as verbal jigsaw and semantic tapestry. I learnt that these are good questions in a science classroom but need to be asked at the right phase of the lesson (when the students have some understanding of the foundational concepts).

### 4.4.5 Giving instructions to students for the teaching and learning activity

Right towards the end of the first lecture, I asked students to talk to each other about "everything that we did" as a means of concluding the lecture. This instruction was not displayed on the screen. I had just finished explaining the last slide of the PowerPoint presentation. I did this just after I asked students to raise questions if they had any, as shown in the excerpt below:

**(1) Student:** *Ehhh Mr Khoza, you talked about the organ of Corti, what does it contain?*

**(2) Lecturer:** *It contains the hair cells. If you look at this diagram here, this is this, and you find hair cells in that. So if we take the basilar membrane, we have the organ of Corti because it contains the hair cells. Questions??*

*[Silence]*

*Okay talk to the person next to you about everything we did. So, just rephrase in your own words.*

After the instruction, most students just looked at me. I then repeated my instruction, thinking that they did not hear or understand what I wanted them to do. I overheard one student in the front row asking her friend: *"What are we doing?"* Instead of discussing some students started to pack their bags in preparation for leaving the lecture room. In less than a minute, students were leaving the lecture room, and more students followed. We never had a chance to go back to what I requested them to do.

**Bheki:** *Is this how you ended your lecture? Lessons normally have phases until conclusion and conclusions sometimes have activities.*

**Jane:** *It is good that you realise that your conclusion of the lecture was not well-planned. But what will you improve and do better next time and how?*

**My reflection and lessons learnt:** I thought I was giving students an opportunity and the autonomy to discuss what they did not understand and to ask each other questions and learn from each other. Instead, the students thought that by asking them to discuss the content we had covered I was closing the lecture whereas I aimed to get them to talk and share ideas. However, the moment they started talking, they also started packing their bags, I was able to see that they were not talking about what I asked them to. As I read Bheki's comments, I realised that when ending the lecture, I should have a proper conclusion. I realise that guidance in terms of questions is important for the students to consolidate their understanding. I also realise that this could have been a significant opportunity for students to ask questions where they did not understand something and important for me to test their understanding even if it is of one concept that was covered. Jane's comment made me realise the necessity of planning the lecture from the introduction to the conclusion. The importance of a conclusion is to summarise the main ideas of the lecture. I now understand that an effective discussion is one that is guided by clear instructions regardless of the level of students. According to Rosenshine (2012), giving clear and precise directions on what students need to do does not only provide students with the necessary scaffold but also helps the instructor, later on, to judge the expectations to provide evidence of learning and progression. Besides the instruction, I need to give students direction on what they need to discuss. These indicators can be included in a slide showing several questions that summarise the focus of the lecture or concepts that were problematic for students to understand.

Furthermore, I realised that the activity still needs to be mediated in such a way that students can be directed in the right direction during and after the discussion; hence the importance of feedback

afterwards. In this way, students benefit from doing the activity because they have clear direction on what they need to do. Clear instructions about an activity can determine the level at which students engage with the activity for their understanding.

### 4.4.6 My struggle in facilitating question and answer sessions

In my lectures, I used questioning as a strategy. I always asked students questions about the concepts that I was teaching. The question and answer sessions differed in terms of who initiated the discussion – the students or the lecturer. In my one week of teaching, I had observed a unique dynamic in terms of my responses when a student initiated a question for discussion. An example of how a student initiated a conversation in my teaching is shown in this excerpt below coming from the first lecture. This was during the first lecture dealing with the structure of the ear and hearing and how the ear maintains balance.

| | |
|---|---|
| **(1) Student 3:** | *Can I ask?* |
| **(2) Lecturer:** | *Yes sir* |
| **(3) Student 3:** | *It is something stupid* |
| **(4) Lecturer:** | *Okay. I am listening.* |
| **(5) Student 3:** | *Earlier on when we did the brain, I don't know, they mentioned cerebellum has to do with something like movement, and you say the ear helps us for balance. So, I am confused...maybe there is a connection between cerebellum and cochlea? How so?* |
| **(6) Lecturer:** | *What is the function of the cerebellum?* |
| **(7) Student 3:** | *It maintains, they say...it maintains your posture.* |
| **(8) Lecturer:** | *And it is part of the brain...So, the way you are seated there is detected by your brain but interpreted in some parts of the brain. So, the ear sends the signal to the brain to say this person is seated this way. And we will do that on Friday. Of course, if you come. Yes sir?* |
| **(9) Student 4:** | *You are saying that the ear enables us to keep our balance. Can you elaborate on that and give some examples?* |
| **(10) Lecturer** | *I will do that on Friday because today we are only covering the structure of the ear and how it helps us to hear. Yes mam, last question?* |

The extract above shows that the student started a conversation by asking a question in turn 1 although he was not confident that this is the question he should be asking (turn 3). Although students 3 and 4 were ready to engage with the concept of how the ear controls posture and balance,

this was not the focus of the lecture (turn 8 and 10). The students did not like the way I dismissed their arguments, as expressed by Students 40 and 43 below.

> **Student 40:** *I would say the only thing you have to alter is your response to students' responses to your questions as your lesson will have a lot of students who are disengaged.*
> **Student 43:** *You need to try to have a way of answering students' questions without confusing them more. Do not 'park' students' questions because don't go back to them later.*

**My reflection and lessons learnt:** It initially seemed like the students' engagements were going to derail and even shift the focus of the lecture. I now realise that student 3 (shown in the excerpt) was interested in the link between the cerebellum as part of the brain (as learnt in the previous topic with Eunice) and the function of an ear to control posture. I could not connect these links because I wanted to teach the concept in the second single lecture. I missed an opportunity to make links between what the students have done to what I am doing. I realised that I do not have to "park" questions but make links at that point or allow the students to note down the question as a way to remind me later in that lecture or another lecture. This realisation has made me reflect and fine-tune the way I conduct my answer and question sessions. This is important because learning is embedded in such interactions and meaning-making begins by asking and responding to questions in the classroom. Questioning is a known pedagogical practice and strategy used in classrooms to evaluate students and involve them in the lesson (Larson & Lovelace, 2013).

### 4.4.7 The significance of learning from *testing the waters* after observing experienced teacher educators

In this section, I have presented the lessons learnt from my practice of *testing the waters* after reflecting on my experiences as an undergraduate student. The first key point to make is that through teaching the one-week topic, I discovered certain practices and re-constructed my thinking about certain practices. For example, I have attempted designing PowerPoint slides that would lead to interaction and in the end still realised that the effect is not as envisaged. This then called for new ways of thinking about certain practices of teaching biology to pre-service teachers and making pedagogical decisions. Oleson and Hora (2013) remind us that these attempts and quests for finding how to do things in teaching are a foundation for learning and developing one's professional practice. One would term what I did as a trial-run approach to learning. According to

Murray and Male (2005), this kind of an approach is a component of learning in self-study as it involves critical self-reflection. As I was teaching the pre-service teachers, I had to make certain decisions without having an idea of how the results would turn out to be. The main observation here is that a shortened period of teaching, as a trial run, is indicated in a sense that the novice teacher educator can try out those personal theories, that is, theoretically-unfounded pedagogical practices in a trial and error.

Upon reflection and engaging the others these practices are revealed for critical examination for learning (Schuck, Aubusson & Buchanan, 2008). The others, in this case, include the pre-service teachers I was teaching. I would not have gained insights if I did not use their feedback as a lens to look at my teaching. Seeking continuous feedback from students helped me to learn about practices that would form a foundation of my subsequent teaching. The students' feedback acted as another 'lens' to look at my teaching and the pedagogical decisions that I was taking in practice.

Although the lessons learnt about the practice of teaching biology to pre-service teaching from reflecting on my experiences formed the foundation for my learning, certain practices still needed further exploration. For example, I identified how I was unable to ensure continuity of concepts when facilitating question-answer questions. This is because when I was observing the teacher educators, I did not focus on specific aspects of practice. There is a need for continuous observations and practices of a novice teacher educator. That is for one to observe and practice then reflect and observe again.

## 4.5 CONCLUDING REMARKS

The essence of this chapter is on how learning to teach pre-service teachers can be achieved by exploration. In this chapter, I have illustrated how I learnt the practices of teaching biology to pre-service by exploration. The exploration was through:

1. Reflecting on my experiences as an undergraduate student
2. Observations of other biology teacher educators' lectures
3. Planning and teaching a biology topic for a short period
4. Continuously requesting student feedback about my teaching.

Reflecting on my experiences as an undergraduate student helped me to learn and the conclusion there is that part of learning to teach as a novice teacher educator is to critically look back at the practice not just as a student but to figure out what the purpose of certain activities and practices experienced when one was a student really was. There is a lot of naivety and immaturity when one is a student as the focus is on passing the course. This changes when one is now a teacher educator engaged in reflection. Observing the experienced teacher educators' lectures to explore provides opportunities for a novice teacher educator to gain invaluable insights from these experiences. The fact that I went into teacher educators' classroom with no pre-determined focus areas helped me to look at practice from different angles and note down all dynamics of teaching pre-service teachers. However, this explorative way of learning has shown that there are other dynamics of teaching pre-service teachers that I could not focus on. Learning by doing the actual teaching in a *trial and error* approach and exploring pre-service teachers' feedback on my teaching works in the sense that one tries out certain teaching approaches. Through reflection, the insights obtained form a basis for further exploration. In the following chapter (Chapter 5), I present insights gained from doing the second round of exploration, that is, observing the teacher educators again and having formal discussions with them.

# CHAPTER 5: FROM THE GENERAL TO THE PARTICULAR: EXPLORING SPECIFIC PRACTICES IN EXPERIENCED TEACHER EDUCATORS' LECTURES

## 5.1 INTRODUCTION

In the previous chapter, I presented how I gained insights about teaching biology to pre-service teachers through exploration that involved reflecting on my undergraduate experiences as a pre-service teacher, observations of experienced biology teacher educators' teaching, planning and teaching a biology topic for a short period and continuously requesting student feedback about my teaching. The insights gained, especially from my one week of teaching, revealed some aspects of practice that needed further exploration. Hence, I did a second round of observing teacher educators' teaching to learn about specific practices of teaching biology to pre-service teachers before hers. The teaching practices that I wanted to focus on included 1) how interaction of students with content can be promoted during lectures, 2) how question and answer discussion for the whole class can be facilitated effectively, 3) how biology terminology can best be handled and 4) how teaching practices can be modelled during biology content lectures. I begin by describing the data collection and analysis procedures before presenting the insights gained from these observations. I then discuss the significance of focused observations in learning to teach to conclude the chapter. This chapter addresses the first two research questions:

1. What do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?
2. How do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?

## 5.2 DATA COLLECTION AND ANALYSIS

Data was collected through *silent participation* during biology lectures. I would sit in the lectures of participating lecturers and write down observations specifically about the objects of interest as outlined in the introduction to this chapter. The number of observed lectures per teacher educator is indicated in Table 3.1 in Chapter 3. Immediately after the lecture or as close as possible to each observed lecture, I would use the observation notes to produce narratives that would explain what

I observed in the teacher educators' lectures. For this chapter, I chose the narratives that captured effective strategies for achieving the specific practices outlined in the introduction. The narratives also contained my initial interpretation and reflection.

## 5.3 PRESENTATION OF INSIGHTS

Following the description of how the data was collected and analysed, I present the narratives that capture my observations and my reflections and insights from the observations.

### 5.3.1 How the interaction of students with content can be promoted during lectures

The purpose of the focused observations of lecturers' teaching was to observe and document how they promote student engagement with the biology content they teach. As I have indicated in Chapter 4 Section 4.2.1 that I had realised that there must be a variety of ways to foster student interaction (the design of a PowerPoint presentation being one of those ways). I wanted to learn how one can promote interaction and engagement in biology lectures. Khoza and Nyamupangedengu (2018) used the term "instructional prompts" to describe the variety of teaching practices that promote engagement and interaction during a lecture. Below, I present examples of the instructional prompts that I observed from which I drew insights on how interaction can be promoted during lectures. Some of the prompts were common across the teacher educators, and some were unique to a specific teacher educator. It is important to note that these prompts were published in a paper by Khoza and Nyamupangedengu (2018). In this thesis, I am adding my reflections and what I learned about promoting interaction in lectures. Hence, for each prompt, I narrate how it was used in the teacher educators' lectures followed by my reflection and insights gained.

#### *5.3.1.1 Prompt 1: Conversational stories*

**My narrative:** Mariam was teaching about the structure and functions of different parts of the brain. She used narratives of novel stories and requested students to figure out the function of the part of the brain from the stories. As an example of the use of stories, I noted that the students were given the story: "Kuda is a student doing BSc and wanted to sound complicated to his friend doing BA law. So he said: 'Tabang, I have an exam on Monday, so no chilling out for me this weekend. I have to go to the library to grow the **dendrites** in my **cerebrum** in preparation for the exam."

The part of the brain was bolded or underlined in every story to focus students' attention and to remind them about the biology concept that they needed to focus on. The story caught students' attention and stimulated their thinking, as indicated by students gesticulating and arguing passionately with their peers. It should be noted that the use of conversational stories was only observed in Mariam's lectures.

**My reflection and insights*:*** This is a typical example of how I can facilitate interaction that is informed by meaningful engagement with the course content. The stories seem to have acted as tools for capturing students' attention. It became clear to me that for a story to create interaction in a biology classroom, it needs to be linked to science (biology) content which has the potential to move students beyond just verbal communication to engagement for learning. Helme and Clarke (2001) note that gestures externalising thought processes are one of the signs of showing engagement. Students' cognitive engagement, in Piaget's terms, is evident when they make evaluative comments and contribute ideas during the student-teacher interaction. This leads to a form of engagement where students will not only identify the brain function but also ask inquisitive questions like "Mam, does it mean that when we study for an exam, we store the information in the cerebrum?" In addition to the fact that the narratives acted as tools to capture students' attention, the narratives helped the teacher educator to explain abstract concepts (Avraamidou & Osborne, 2009). Students saw the cerebrum not only as a "container" for storage but also as a place where information is processed. Equally, by using stories, students were able to see the relevance of the topic to their everyday lives.

I learnt that it is not only about the use of stories but also the content and the nature of the story that determines its relevance to students and students' construction of mental images. The formation of mental images is important for learning (Zabel & Gropengiesser, 2015) as the mental images are then used by the students as they participate in the discussions. In this way, students tend to retain the content constructed during the interaction because of the narratives and because students direct the interaction through the answers they provide. However, the fact that these stories were only observed in Mariam's lectures raised questions. Besides the fact that the construction of these stories takes time and requires specific expertise, the nature of the topic and the lecturer's objectives and what they would consider as effective strategies for teaching their

topics matter. From this, I learn that I need to also think of the topic I am teaching and my objectives for using certain instructional prompts.

#### *5.3.1.2 Prompt 2: Video clips showing natural phenomena*

**My narrative:** John was teaching environmental studies. He regularly used video-clips to involve students in his lectures. In one of the lectures, he played a video-clip called "Anthropocene" then used it to explain the environmental crisis that the world is facing. "Anthropocene" defines a period when the earth experienced human impact based on gathered evidence. After explaining what was in the video clip, John asked the students to discuss their thoughts on it and then requested them to give feedback. Although some students were able to participate, the participation was limited. Leila also showed students an animated video explaining the timeline of evolution from the first organism on earth in her second lecture. The video was five minutes long. Instead of playing the whole video, she stopped at specific points of the video and asked students questions. She still used questions like "Think about this for a minute and let us discuss…" (See Chapter 4 Section 4.3.4). In both John and Leila's lectures, there was student interaction when they used videos. In my initial reflections, I asked myself the questions: Could the provision of a silent episode to allow students to think and to gather together their ideas before calling for a discussion and feedback have made a difference to the level of participation?

**My reflection and insights*:*** The level of participation in Leila's lectures was intense as she gave them a time to think. From these observations, I learnt that it is important to give students time to think of what they have watched. As they think, they restructure their ideas. There is no doubt that the use of video-clips works in promoting interaction in biology lectures. However, I realise that these videos need to be accompanied by questions. This can be in the middle of the video or at the end of the video. It is also not just about the videos or any other teaching and learning aid but how the videos show the applicability of the biology content that is learnt to real-life situations. My understanding is that teaching and learning aids like videos that are well linked to everyday situations are likely to stimulate students' thinking because the students can easily relate to what they observe in real-life situations (Isiaka, 2007). However, I noticed that the interaction would have been more intense in John's lecture if students were requested to watch the video and make notes before coming to the lesson as this would have allowed students to come prepared with questions from their cognitive engagement with the teaching and learning aid. Nevertheless, the

key characteristic of interaction that I learnt from John's use of a video clip is the choice of the clip. I learnt that when I need to choose video clips to aid my teaching, I do not need to use substitute videos that show someone teaching the concept. Instead, I need to use videos that give students an explanation of a natural phenomenon, just like John used a video that portrayed the environmental crisis.

#### *5.3.1.3 Prompt 3: Worksheets and lecturers' instructions*

**My narrative:** Mariam had just finished teaching about sensory organs and wanted to consolidate the concepts in her last lecture. Towards the end of the lecture, she gave students an activity accompanied by a worksheet. The worksheet had a table in which the different types of stimuli formed row headings and the terms *receptor*, *effector* and *response* formed column headings. Students were given heat as the stimulus and had to fill in the receptor, the effector and the response. Mariam gave students a choice of either discussing it with their peers or working on their own. Students were talking to each other, pointing at the worksheet and filling in the table. Students were asked to write down their answers so that they could later refer to them during the feedback session. During the class discussion, students were reading their answers from the worksheet and motivating their answers. Students used phrases like "we wrote...because" as they read out the answers they had written in their worksheets. Students used their own examples to argue for their answers. John also gave students activities. When John was teaching the topic of planetary boundaries, he displayed an activity to match the terms in Column A to their descriptions in Column B on the screen and immediately asked students to discuss the activity for 10 minutes, after which feedback was required. Although there was interaction promoted by the activity, it was minimal. A student would say: "A matches with E" and it would end there. The interaction did not go beyond communicating science ideas because of missed opportunities like asking students to think about "why". So, the interaction took a format that indicated just a recall of the content learnt, which may not necessarily mean that the activity resulted in engagement for learning.

**My reflection and insights:** The types of interaction that played out in Mariam and John's lectures showed that, besides the provision of tangible material like the worksheet, the lecturers' instructions accompanying the teaching and learning activity played a role in fostering a specific type of interaction. In John's lecture, the students were not provided with options on how the activity was to be done. The verbal instruction from the lecturer was: "*Do the activity with your*

*neighbour"*. The students were required to match the words in Column A to those in Column B. There was no indication that students needed to think about the "why" for their answers. Hence, the result was students giving one-word answers that fostered rote learning or recall of science facts because it is what they were requested to do.

In contrast, in Mariam's lecture, students were allowed to either talk to their neighbours or "talk to themselves". Students who I saw completing the activity alone still contributed during the whole class discussion. This showed that students were able to interact with their thoughts and that their worksheets acted as a vehicle for the interaction. Therefore, social interaction as well as cognitive interaction was established when the students were engaging with the teaching and learning material. The key insight emerging concerning this observation is that while the activities guided by worksheets as prompts to trigger interaction work for engagement, teacher educator facilitation and scaffolding through instructions is crucial. As argued by Van de Pol, Volman, and Beishuizen (2010), to achieve desired outcomes, scaffolding tools are necessary. I witnessed real-time engagement for meaningful learning from Mariam's lectures which was a direct result of the interaction between students, interaction with the teacher educator, and engagement with the content. Thus, to have interaction that promotes meaningful engagement, students need to be allowed to first engage cognitively with the aid or the activity. Providing students with opportunities for cognitive interaction by allowing them time to first interact individually with tools like worksheets and visual aids before vocalising their thoughts in a socially mediated environment can move students beyond just interaction to engagement for learning.

### 5.3.2 How a whole class question and answer discussion can be effectively facilitated

Having noticed how teacher explanations, asking questions, and facilitating a classroom discussion can be challenging (see Chapter 4 Section 4.4.6), I went into the experienced teacher educators' lessons to understand the best possible ways of facilitating question-answer sessions for students' learning. In the teacher educators' lessons, I observed different ways in which the teacher educators responded to students' questions and gave feedback to the students' answers. Below, I narrate how two teacher educators did this.

**My narrative:** Alice was teaching homeostasis to a group of third-year students (the same group that I taught). When one student asked her a question that perhaps was not related to what she was

talking about at that moment, her response was: “a very good question…hold it, for now, will come back to it just now…” or she would say “ohhh…yes…you are now talking about…will get back to that tomorrow”. In such cases, perhaps when she thought the question was significant, she asked all the students to jot down the question for future reference. When she asked students a question and students answered she would say “you are saying this…” and rephrase the students’ answers then get another student’s answer. At a later stage, she would say “let me repeat the question…now let’s go to the answers we got.” Key points of the answers were written on the board**.** During the second lecture of Mariam when she was teaching about neurons and asked students the difference between the three types of neurons, one student answered and Mariam responded by saying “Why is his answer wrong?” Another student then responded “Ahh mam…is it wrong?” and Mariam responded: “Yes, there is something about the answer that makes it wrong all together” In the third lecture, one student gave the correct answer. She still said the same thing “What makes this answer correct?”. At first, I thought Mariam would only ask students to “analyse the answer” if it was incorrect. To my surprise, she did the same thing with correct answers by telling students that the answer is correct but asking them what makes it correct.

**My reflection and insights:** The strategies that the teacher educators used seem to come back to two underlying factors; having a robust understanding of the content knowledge and being aware of discursive moves that facilitate interaction (Tytler & Aranda, 2015). When Alice set reminders, she explicitly noted how a question links to other concepts that she is yet to teach before she could “park” the question for later reference. I learnt that, as a biology teacher educator, parking the question and referring to it later would require a robust understanding of links between the biology concepts. When the student asked me a question about the brain as presented in Chapter 4 Section 4.4.6, I could not provide a worthwhile response to the student despite stating *“We will cover than on Friday,”* because my understanding of concepts in the topic of the human ear was fragmented. A strong understanding of the content knowledge would assist me with involving myself in immediate reflection on the student question before dismissing the question. I need to understand the key concepts that are important for students to learn. Mulliner and Tucker (2017) have observed that this kind of knowledge is the cornerstone of any teaching endeavour. Hence, I need to understand the links between these key concepts and how they influence one another.

In Mariam's lessons, what intrigued me about the way she responded to students' answers was her being explicit and upfront with the students about how she understands their answers and indicating whether the answer is correct, incorrect, or partially correct. In addition to having a robust understanding of the content, a knowledge of discursive moves helps the teacher educator decide which moves to take. Literature around classroom discourse indicates that just stating if the answer is correct or wrong is the "E" in Initiation Response Evaluation patterns and do not help the students to learn. What helps the students to learn is the exploration of students' ideas and the replacement of an E with an F-feedback where the student is told why the answer is wrong (Bansal, 2018; Ramli, 2017). The insight gained here is that I need to go beyond using the F in the IRF triad. Instead of correcting the students' answers myself, I can ask the students to engage themselves in what I called "analysis of the answer" like Mariam. Therefore, students can still be questioned even if their responses are correct to strengthen their understanding of the biology content.

### 5.3.3 How biology terminology can be handled

Having discovered that I had not gained specific strategies on how to deal with the technical biology terms (see Chapter 4 Section 4.4.2), I wanted to find out how experienced teacher educators handle the biology terminology in their lessons. Below, I narrate what I observed from the teacher educators in terms of dealing with the terminology in biology and extract those strategies.

**My narrative:** Leila was teaching human evolution. In her lectures, she became upfront with students and told them that the terminology in evolution is hard to grasp and to pronounce, especially the scientific names of the fossils. She always asked students to write down the term that she would verbally say (e.g. Australopithecus). With the terms that have structural or functional derivatives, she started with the derivative and went back to the scientific term to help students remember the term. The structural or functional derivative means a term was constructed from the structure or functional role. For example, Pteranodon was associated with a toothless creature with wings. When Alice introduced the topic of homeostasis, she asked students what they understood by homeostasis, and none of the students wanted to answer. She then broke the word into homeo- and -stasis. This is when one student answered that –stasis may mean static. In Lecture 4, Mariam brought concrete material to illustrate the generation of a nerve impulse. She

brought a pool noodle that was cut longitudinally. She used pins of different colours on the outside and on the inside to illustrate different ions in cells. As she was explaining with the aid of the pool noodle, she wrote the key terms on the board. She later used these key terms to write key processes in sentences. Most of Gracious' PowerPoint slides had a written list of terms (e.g. cytoskeleton, centrioles) that she used during the lecture at the end. Instead of a definition, these terms had descriptions. Sometimes in the middle of the lecture, she would tell students to write a particular term down. For example, when she was introducing how molecules cross the plasma membrane, she said: "Write these two terms down [osmosis and diffusion], we will come back to them shortly". She later requested the students to write down their definitions of the terms.

**My reflection and insights:** The teacher educators used a variety of strategies to deal with biology terminology. From the observations and the narratives, I have categorised these strategies as shown in Table 5.1 below.

**Table 5-1**

**Strategies used by teacher educators to deal with the biology terminology**

| Category of the strategies | Examples |
|---|---|
| Visual – aided strategies | Using the concrete materials like strings to explain a chromosome, chromatin and DNA; pool noodle to explain channelling of ions |
| | Using a picture to show the *function* |
| | Using the actual skull to show where the term was derived |
| Strategies that involve talking and writing | Using more common terms before *scientific terms* |
| | Using analogies and metaphors |
| | Vocalising the term and breaking it down |
| | Continually asking students to write down the term as the lecturer says it and later on define the terms |
| | Requesting students to highlight the key terms in the PowerPoint slides |
| | Requesting students to say the term loudly |

As it can be seen in Table 5.1, the teacher educators used a variety of visual-aided pedagogical approaches to deal with the biology terminology. A lesson for me is that one can use visuals to help students remember and make sense of the biology terms. However, I need to pay attention to the nature of the visual aid. Concrete materials as visuals help students to remember because they would have formed mental images. What I have noticed is that the terms that were explained using visuals were related to structures. For example, a chromosome as a *structure* that one can visualise was explained using strings. From this observation, I learnt that it is important as a teacher educator

to first understand the nature of the term before finding strategies that could help students remember the term.

Students need to be able to communicate the terms, be able to write the term. One of the key factors that contribute to students' difficulties in learning biology is not being able to write the correct spelling of a term such that the written version of the term changes the meaning of the whole idea (May, Cook & May, 2013; Zukswert et al., 2019). For example, writing a *stroma* instead of a *stoma* would change the idea and meaning of the biology term. What I regard as the key problem for students in dealing with terminology is not being unable to pronounce the term but being unable to write the term and describing it for meaning-making in learning biology content. The insight here is that engaging students in talk and giving them short activities such as defining terms (as they write the definitions) is a good approach. However, I realised that as a biology teacher educator, I could do more than requesting students to write down the terms and define them. Students can be asked to construct a concept map after defining those key biology terms in a topic. This would be a good exercise for them to see a relationship between these terms because understanding the biology terms and their relationship could mean understanding the content of biology itself.

### 5.3.4 How teaching practices can be modelled during biology content lectures

After reading and learning about the concept of modelling practice, I went into the teacher educators' classrooms to find out how (if at all) they model practice explicitly to students. Below, I narrate my observations and initial interpretations then present my reflection and lessons learnt.

**My narrative:** There were a few instances that showed explicit modelling in the teacher educators' lectures. When teaching about senses, Mariam gave students a worksheet that had a column named sense organs: ear, eyes, etc. She said, for those who will be teaching in primary, it is okay to just talk about *the organ* and a similar worksheet with pictures can help learners to engage. So, she used a teaching and learning activity and told them the context in which they can use the activity to model practice to the primary school pre-service teachers. Similarly, Leila asked in the worksheet that she gave to students during the lesson; "How would you use this representation (phylogenetic tree) to teach evolution to your learners?". When Mariam was teaching about the nerve, she brought an electric cord and asked students what it was, and she started explaining when

she realised something and said “Have you all seen this and do you know what it is used for?” Some students said yes, and some students said no. She then explained that this is a lesson for them – to not assume that their learners know something without checking if they do, especially if they are going to teach in a very diverse environment.

**My reflection and insights:** I have seen how practice can be modelled explicitly; through the inclusion of questions that help students imagine their future contexts and by stating how certain pedagogies can be used in particular contexts. What seemed to be the difficult form of modelling as observed, is the last form where the teacher educators need to connect the exemplary behaviour to the theory. Lunenberg et al. (2007) argue that this is difficult because the teacher educators become too focused on the content that they are teaching and looking at how the theory can connect to the behaviour that is modelled. Mariam’s explicit reference to how a worksheet can apply to the primary school learners is one way of modelling practice when teaching content to pre-service teachers. The latter will teach at different levels in schools. It is therefore important for me to be explicit enough so that the modelled practice of teaching biology would be effective in a certain context.

## 5.4 THE SIGNIFICANCE OF FOCUSED OBSERVATIONS OF EXPERIENCED TEACHER EDUCATORS’ LECTURES AS A WAY OF LEARNING

This chapter is about how I learn about specific practices of teaching biology to pre-service teachers by observing teacher educators. The difference between these insights and those reported in Chapter 4 is the *nature of observations*. With these observations, I focused on specific aspects, and this increased my chances of learning in-depth how to do certain things as opposed to looking at the whole practice. I was able to gain more insights about how to promote interaction, effectively facilitate student questions and responses, deal with biology terminology, and model teaching practices because of the focused observations approach. The focused observations helped me to “zoom in” on specific practices that I would not have seen if I did a general observation. Hendry, Bell and Thomson (2014) state that a practitioner fulfilling the role of an observer gains insights that positively impact their practice. The observed practices contributed to the development of my repertoire of practices for teaching biology to pre-service teachers. According to Orland-Barak and Leshem (2009), as one adds to their repertoire of practices, they start to connect to experiences they “see in practice” (Orland-Barak, 2009, p. 23). I was encultured into practice through these

observations as an apprenticeship; therefore, I view observations as learning experiences. The learning experience is in being able to realise the complex nature of teaching because of how a single practice may be seen to manifest differently in different teacher educators' lectures.

Learning through focused observations from experienced teacher educators provided me with invaluable opportunities for my professional development because I continuously engaged in reflective practice that shaped my thinking in terms of making decisions in my teaching. According to Ben-Peretz, Kleeman, Reichenberg, and Shimoni (2010), learning through deliberate observations and reflecting on these observations, including discussions, count as a form of professional development. It is crucial to note that this was a situated, context-based reflective observation. As stated by Kolb and Kolb (2005), learning through observation requires vigorous reflection for one to engage in abstract conceptualisation that should inform active experimentation. Furthermore, Hoover, Giambatista, and Belkin (2012) argue that when learning through observation, one develops an understanding of their practice in relation to the practice of the ones observed. As such, observation becomes an important learning approach and a precursor of active experimentation where there is an implementation of some practices learnt. I have learnt certain pedagogical practices through discussing and observing teacher educators which I later used for planning and teaching – which would be active experimentation in Kolb's terms.

## 5.5 CONCLUDING REMARKS

The main contribution of this chapter is how observations that are focused on specific aspects of practice is an effective approach to learning how to teach pre-service teachers. I have shown how I gained insights into teaching biology to pre-service teachers by observing experienced teacher educators. The observations were focused on specific practices: How interaction can be promoted; question and answer discussion for a whole class can be facilitated effectively; how biology terminology can be handled and how teaching practices can also be modelling to the biology pre-service teachers. I then discussed the significance of observations that are focused on particular practices. In the next chapter (Chapter 6), I present the insights I gained from having a discussion with the experienced teacher educators about planning to teach a biology content course and doing my planning for my three weeks teaching.

# CHAPTER 6: IN SEARCH OF THE PRINCIPLES OF PLANNING TO TEACH BIOLOGY TO PRE-SERVICE TEACHERS

## 6.1 INTRODUCTION

The previous chapter was about the insights I got about teaching biology to pre-service teachers from observing experienced teacher educators' specific practices. Teaching starts with planning. Since I was learning how to teach biology to pre-service teachers, learning how to plan for teaching biology to pre-service teachers was part of this study. The focus of this chapter is about planning to teach biology to pre-service teachers. I present the insights in this chapter to show how I learnt to plan and how I planned to teach a biology topic. The chapter is divided into three sections. In the first section, I present some insights about planning to teach biology to pre-service teachers from discussions with experienced teacher educators. The discussions with biology teacher educators revealed some practices that I could use to plan my teaching. There was, however, one grey area, namely, how to determine the breadth and depth of the content to be taught to pre-service teachers that needed to be explored further. In the second section, I, therefore, present additional insights from exploring how to determine the depth and breadth of content. The third section is a presentation of what I planned for my three weeks of teaching. In the first two sections, I first described the procedures I used for collecting and then for making sense of the data and end the section with a short discussion on the key insights gained and how the learning occurred.

The first section of this chapter address the first two research questions while Section 6.3 and 6.4 address the second and third research question as shown below:

1. What do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?
2. How do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?
3. How does planning and teaching a biology topic help me learn to teach biology to pre-service teachers?

## 6.2 INSIGHTS ABOUT PLANNING FOR BIOLOGY LECTURES FROM DISCUSSIONS WITH EXPERIENCED TEACHER EDUCATORS

I engaged with the experienced teacher educators through a formal discussion to find out how they plan for their lectures and what they consider during planning. In this section of the chapter, I present what I learnt from my reflections on the discussions with these teacher educators. I start the section by describing the data collected and analysed.

### 6.2.1 Data collection and analysis

Data for this section was collected through open-ended interviews as described in Section 3.4.3 of Chapter 3. The interviews were audio-recorded and transcribed. The analysed data was, therefore, in the form of transcripts of the formal discussions with the teacher educators. The interview transcripts were analysed inductively but the formulation of codes was informed by the literature that I reviewed in Chapter 2. After coding one transcript, I presented my coding to Eunice for feedback and validation. Eunice suggested rewording of some codes to capture succinctly what the teacher educator's utterance was revealing about the thinking that goes into planning. She also suggested that I should indicate the practices that I was interested in, such as; how to determine the breadth and depth of content to be taught. Table 6.1 below shows an extract of the revised coded transcript. The first draft of this transcript is shown in Appendix G. The table is divided into three columns. Column one shows the speaker. Column two shows how I was breaking down the utterances to code specific segments (bolded), and column three indicates the assigned codes. I have also indicated in the assigned column, the "practice of interest" to show specific aspects of planning I was interested in and was zooming on as the discussion continued.

**Table 6-1**

**Example of coded raw data (discussions with experienced teacher educators)**

| Speaker | Utterances | Assigned code |
|---|---|---|
| Researcher | So, the big question is, how do you plan for your biology for lectures? | ***Practice of interest:*** how to plan for biology lectures |
| Rose | So, if I think of **how I develop the course**, then I can talk about preparing for lectures because it conceptualises everything | Course outline |
| | So, I have taken the **whole topic of reproduction** | Topic |
| | and I looked at **what is done at school level** | School curriculum |
| | to make sure that the **students who are going to be teachers** | Students as teachers-identity |
| | are covering **basic concepts at school level** | School-level content |

| | | |
|---|---|---|
| | And then I have looked at **what is being done at university** | University content or university curriculum |
| | **Using textbooks** and I have looked at the sort of depth that they go into in **different tertiary level textbooks**, so I have used that as a guide | University textbooks to determine content depth |
| | I have **looked at other institutions** to see what they actually do | Curricular of other institutions |
| | I have **tracked the topics covered** in reproduction | Curricular saliency |
| | and **slipped them up into lectures** all the way through | Curricular saliency |
| | So I have taken...In addition, I **go beyond what is at school-level** | School-level content |
| | So, that is the first thing. And I **look at different concepts and pack them up for each lecture**. So, I have topics on meiosis related to spermatogenesis, oogenesis, male and female reproductive cycle, etc. | Curricular saliency |
| | And then I **take my seven weeks and start to allocate topics.** | Course duration |
| | And I look at **how it gets applied into people's everyday lives**. I look at different diseases, things that can go wrong and all that. | Content relevance to students' everyday lives |
| | Then that is...I need to have topics first for the course, I have to have concepts of what I want to cover in that topic. | Course outline |
| | So, then I start to **jot down key points and key ideas that I want to cover in that lecture** | Curricular saliency |
| **I** | So, when you said you look at tertiary textbooks, what kind of textbooks, what guided your choices? | Practice of interest: choice of university textbooks |
| **Rose** | So, **Campbell and Reece was a very useful textbook,** I have got Raven... | Textbook |
| | So, I have to look at it and **say what information is most relevant and most useful to my students**. So, for example they go into other animals' embryology and I focus on human embryology. | Content relevance and usefulness |
| **I** | So, you said Campbell and Reece went into details and? | ***Practice of interest:*** (choice of university textbooks) |
| **Rose** | Yah, some of the textbooks go into too little detail. So, it is | Textbook |
| | really for my choice. So**, I make a choice as a lecturer** on | Autonomy |
| | **based on my experience** on the number of years | Role of experience |
| | on **how much I can put into that 7 weeks and what sort of detail I can go** into that 7 weeks | Course duration |
| | And **every year I modify it** | Planning as a continuous exercise |
| | **Sometimes I think I have gone into too much detail or too little detail** and I move my lectures around, the order | Role of reflection |
| | So, **I am continually rethinking the structure of the course** and how I develop these concepts | Role of reflection |
| | How do you **go from known to what is not known**. How do you go **from the matric level maybe too much greater depth** that would be most appropriate for 5$^{th}$ year level? | Curricular saliency and student prior knowledge |
| | But not the depth that would become something else...**I have to fit that into 7 weeks.** | Course duration |

| | | |
|---|---|---|
| **I** | So, are you saying that it is because of time? If you had time, you would go into much details? | ***Particular item:*** (how to determine depth) |
| **Rose** | I am not sure if I would. **So, I had to make a choice** | Teacher educator's autonomy |

After the validation of the coding, I then coded the rest of the transcript. Note that I was still open to adding new codes if new aspects were to emerge from the coding of the experienced teacher educators' interview transcripts. After completing the coding, I extracted the codes into one list (see Appendix H for the list). I read through the list more than twice to make sense of the codes and to figure out how I could reduce the list into categories. After going back and forth through the list, I eventually collapsed the codes into four planning practices namely: 1) Consultation of the school curriculum, 2) deciding on how deep and/or broad to teach the chosen content, 3) thinking about the approaches to use and 4) consideration of student prior knowledge. These themes, as results, are published in a conference paper by Khoza, Msimanga and Nyamupangedengu (2020). As I was reading through the codes, I was reflecting on the codes entering my thoughts in my journal. The analysis of the transcripts and the categorisation was accompanied by my reflections which were then transformed into narrative texts. Hence, what I am presenting in this thesis are the insights gained about planning.

### 6.2.2 Presentation of insights

From the teacher educators, I have gained insights about practices that one needs to engage in when planning to teach biology to pre-service teachers. For each of these practices, I present evidence of what the teacher educators said as emerged from the analysis. This is followed by my reflection and insights gained.

#### *6.2.2.1 Planning practice 1: Consulting the school curriculum*

When asked where they start when planning for their courses, three of the four teacher educators said that the first thing they do when planning to teach a biology topic to pre-service teachers is to browse through the Curriculum, Assessment and Policy Statement (CAPS)[17] syllabus documents to familiarise with what the pre-service teachers would teach in schools after qualification. Although the fourth teacher educator (Gracious) did not make an explicit reference to the CAPS

[17] Curriculum, Assessment and Policy Statement is the South African document that outlines the content that teachers need to teach for each subject and grade. It also outlines the assessment guidelines.

document, she said; "*the students should be prepared in line with the content they need to teach in their respective schools"*. The idea is to make sure that the content they teach to the pre-service teachers covers the content that the pre-service teachers need to teach in schools.

| | |
|---|---|
| **Rose:** | *I look at what is done at school-level to make sure students are covering basic concepts at school-level, I would start with a basic plan of what they need to know at the school-level.* |
| **Leila:** | *I would be guided by the CAPS document, my content will be aligned to what they need to teach.* |
| **John:** | *The CAPS should have an influence on the university teachers' curriculum, start off with the CAPS.* |

**My reflection and insights:** The responses above from teacher educators made it clear to me that it is important to consult the CAPS document, which is the main curriculum document for South African Schools. I learnt that I needed first to study the CAPS document and look at the content under the topic I am teaching. However, I noticed that the teacher educators only consult one of the two curricula that are generally followed in South Africa, that is, CAPS and not the Independent Examination Board (IEB) which most independent schools use. This observation confirms findings from Nyamupangedengu and Lelliott (2018), which indicate that it is necessary to consider the school curriculum when planning to teach biology topics to pre-service teachers. The insight that I gained from their responses and reading the paper by Nyamupangendegu and Lelliott (2018) were invaluable for my planning in the sense that I became aware that I needed to consult both documents in my planning to teach a biology topic to pre-service teachers. I had to do my research and understand the two syllabuses to make sure that students are equipped effectively to teach the content inherent in each of the two syllabuses.

#### *6.2.2.2 Planning practice 2: Deciding on how deep and/or broad to teach the chosen content*

The teacher educators made me aware that the university practice is such that they get a topic and a short description of the aims of that topic from the Head of Department and the University's Rules and Syllabus booklet. If one is lucky, they can also get previous teaching materials such as PowerPoint presentations, tutorials, and practical activities. The details of the content that one needs to teach is not clearly stated anywhere. Teacher educators, therefore, use university textbooks to guide their choice of content that will fulfil those aims. When I asked the teacher educators how they decided on the concepts to include in their course, I found that the teacher

educators struggled to determine the depth of the content knowledge to be covered. From the discussions, I got to realise that that teacher educators use different approaches to guide their decision on the depth of the content. For example, Rose is guided by her experiences as a student and as a lecturer while Gracious looks at whether the students are first year or final year students to decide on the depth of the content.

| | |
|---|---|
| **John:** | *Consider probably less depth and create more time for expansion on some of the topics and teach students how to learn…the time you have* |
| **Gracious:** | *It depends on the year of study of the students…if they are first years or fourth years* |
| **Leila:** | *Depth will bring them to the core science, broader might give them the wider view, and they do not need to know about that [too deep] level of knowledge because they also focus on how to teach that to another child. It would depend on the year I am teaching* |
| **Rose:** | *Expand the topic to give students a much bigger picture, we go broader, I make a choice as a lecturer* |

**My reflection and insights*:*** It is clear from these observations that teacher educators do not have a uniform procedure that informs them how to decide on the depth of the content that they are teaching. If anything, their responses were very vague and therefore not very helpful for a novitiate. For example, Gracious said "it depends on the year of study" but the question remains if a student is in first year or 4$^{th}$ year, how do you determine depth? The approach that Rose uses – depending on her experiences – to decide on the content is problematic since there is no theoretical frame that she uses besides relying on her experiences. I have observed teacher educators teaching the same topics (e.g. cell biology and evolution) that I did in my undergraduate studies, and the content seemed to be different from what I did as a student. If I did not have these discussions with the teacher educators, I would not have known about this struggle. I have realised that there is no uniformity in the way teacher educators decide how deep they should teach the chosen content. Whether to go deep into a single big idea or not and whether to allocate more time to the teaching of a particular concept or not was determined by the quality of pre-service teachers' prior knowledge about that concept.

The insight here is that while topics to be covered are outlined in the university's rules and syllabuses booklet, the decision on the depth and breadth of the content to be learnt by the pre-service teachers seems to be left to the individual teacher educators at Wits. Rose and the other experienced teacher educators did not necessarily help me in deciding on the depth or broadness

of the content because I do not have any experience of teaching pre-service teachers. I thought there is a document that specifies for them what exactly to teach at each level of their studies, and there is someone who compiles this document. I realised that it was my decision at the end of the day. However, how do I come to make those decisions? This question motivated me to explore further how one can decide on the depth of content to teach pre-service teachers. The insights are presented in Section 6.3 of this chapter.

*6.2.2.3 Planning practice 3: Thinking about the approaches to use to teach the chosen content knowledge*

There was evidence from the discussions that teacher educators think about the teaching approaches that they would use to teach the content during their planning. Some of the pedagogical aspects as observed in the teacher educators' lectures presented in the previous chapter (e.g. using videos to teach, preparing and using worksheets) are thoroughly thought out before-hand. This did not surprise me at all as the bulk of planning to teach is about transforming the content knowledge by finding approaches and strategies that would best suit the content, the students and the context that one is teaching in. Hence, the teacher educators, explicitly and vividly, emphasised the need for rational thinking on the teaching approaches and strategies to be used in delivering the course content.

> **John:** *Then the next thing is to think about the methods. Are you going to use lectures, are you going to make it student-centred approach? Are you going to give students a lot of activities?*
>
> **Leila:** *How I teach must be modelling for the students on how to teach; use different teaching strategies then modelling the behaviour, practices and methodologies. Therefore, to unpack what I am doing for them, I would stop and say, do you see how I taught this? So, I unpack what I am doing for them.*

**My reflection and insights:** John helped me realise the kind of thinking that goes into planning to teach a biology topic. This confirms what I learnt from literature that during the transformation of content, the thinking is centred on students (Shulman, 1987). In addition, Rose gave an example of teaching reproduction and noted that one needs to think about "modelling things" to help students understand. *Modelling* is a teaching activity in science, whereby an abstract concept is explained using concrete objects or some form of visualisation (Gilbert & Justi, 2016). From this, I learnt about the importance of teaching strategies and using concrete materials such as the

showing students the actual quadrat when teaching. Furthermore, I learnt how it is important to think thoroughly about these during the planning phase.

I learnt from Leila that pre-service teachers should be taught how to teach, and this should not only happen in methodology courses but also in content courses. Therefore, in planning, I need to be conscious of the teaching approaches and strategies. She further argued: "To unpack what I am doing for them, I would stop and say do you see how I taught this*?"* This is what Swennen et al. (2008) called congruent teaching. They further described this as modelled teaching. As a teacher educator, I must explain the underlying pedagogical choices to my students. That is, I must explicitly tell students why I am using specific approaches and why those approaches are appropriate for the topic. I learnt that this has to be an intentional move which, according to Loughran (2006), is significant when teaching pre-service teachers. Hence, part of deciding on the approaches to use when teaching the pre-service teachers involves thinking about strategies to explicitly model practice to the students. It is through explicit modelling that pre-service teachers get to know why specific pedagogies are used. Modelling the act of teaching includes explicitly unpacking the teaching approaches for pre-service teachers. According to Nyamupangedengu and Lelliott (2016), modelling practice is crucial even when one is teaching a content course. I present the teaching approaches and methods that I decided on in my plan in Section 6.4 of this chapter.

#### *6.2.2.3 Planning practice 4: Consideration of student prior knowledge*

Just as I gained insights from reflecting on my experiences and observing the teacher educators about the significance of prior knowledge, all four teacher educators talked about students' prior knowledge and its significance in planning. They indicated that it is important to figure out what students could bring to the lecture. This is just one aspect of the knowledge of students of which the teacher educators made me aware.

| | |
|---|---|
| **Leila:** | *I have to then figure out what they already know and how I am going to surface that information, especially in science.* |
| **Rose:** | *One of the things that you need to know is what they have done before. What can you build on? What is appropriate that would enlarge and expand students' ideas?* |
| **John:** | *Without considering their prior knowledge when teaching, you are likely to be a bad teacher because you cannot tell how deep you have to go.* |

**My reflection and insights*:*** The teacher educators confirmed and emphasised the student prior knowledge, but I was already considering student prior knowledge during planning. It was of no doubt I had to have a sense of student prior knowledge when planning to teach biology. This includes possible student misconceptions. I learnt from reflecting on my undergraduate experiences presented in Chapter 4 that one can gather prior student knowledge by giving students small activities. The three teacher educators did not enlighten me on other ways in which such knowledge can be gathered. Only Gracious confirmed my earliest insight by indicating that I can give students an assignment before the teaching commences to collect their current thinking. I, therefore, had to explore ways in which I could gather the knowledge of students, including prior knowledge. My understanding was that possible student prior knowledge would inform decisions about the content the pre-service teachers need to learn.

### 6.2.3 The significance of learning about planning through formal discussions with experienced teacher educators

This section of the chapter was about the insights gained about planning to teach a biology topic to pre-service teachers. I learnt the following:

1. To determine the content to be taught, teacher educators refer to the school curriculum documents such as the syllabus
2. To determine the depth of the content of a topic, teacher educators refer to the tertiary level biology textbook. *It was, however, not clear how the teacher educators determine the depth of content to be taught to pre-service teachers. This then became the main focus of exploring how I can decide on the depth and breadth of content to teach to the pre-service teachers*
3. Teacher educators have the autonomy to decide on the sequencing of concepts and methods of teaching.
4. Teacher educators consider students' prior knowledge as a basis for deciding on teaching methods. *It was, however, not clear how I could access the student prior knowledge. This again became part of my exploration to find out how to access this knowledge and how this knowledge could inform decisions on the content to teach the pre-service teachers.*

5. Teacher educators consider students' future identity of being biology teachers and think of ways of modelling practice as part of their planning and teaching.

The five key points above indicate the insights gained from the discussions with experienced teacher educators. These discussions helped me to realise one of the key insights, that I ultimately gave attention to when doing my planning, that deciding on the concepts that the pre-service teachers should learn is challenging. This is because the teacher educators are given the autonomy to decide on the content without explicit guidelines for that process.

I was engaging in dialogue with experienced teacher educators and this positively impacted my knowledge of teaching pre-service teachers. Likewise, Cajkler, Wood, Norton and Pedder (2013) found out that this is the case with teachers who engaged in collaboration and dialogue. The fact that the discussions also involved the teacher educators posing questions for me to think about reflecting the collaborative way of learning. Although the bulk of the discussions was on my learning, their ability to voice out why they do certain things and exposing their uncertainties in undertaking certain tasks when planning was a highlight for me in understanding the kind of aspects on which I needed to focus. Therefore, what came out of this exploration was not only for my learning but also for the experienced teacher educators with whom we share the same interests and common goal of developing our repertoire of practices for planning and teaching biology to pre-service teachers.

## 6.3 EXPLORING A SPECIFIC PRACTICE OF PLANNING: DECIDING ON THE CONTENT THAT PRE-SERVICE TEACHERS NEED TO LEARN

In the previous section of this chapter, I have presented lessons learnt about planning to teach biology to pre-service teachers from engaging in formal discussions with experienced teacher educators. There is a specific practice of planning that I could not get from the discussions with the teacher educators, that is, determination of the depth and/or breadth of the content that pre-service teachers should learn. In this section, I present a description of how I explored my practice of planning, focusing on this specific aspect of planning.

### 6.3.1 Data collection and analysis

The data used to describe the process I engaged in were embedded in the journal entries, discussions with critical friends and the planning documents I was producing. In the planning process, I recorded descriptions of the journey and my thinking that included planning notes and teaching ideas (see Figure 3.2 in Chapter 3). I continuously discussed these planning notes with critical friends, especially the critical friends who were subject experts. During the discussions, we focused on the aspect of how to determine student prior knowledge and the depth and breadth of the content that the pre-service teachers need to learn. I then reflected on the discussions with my critical friends after which I documented the lessons.

### 6.3.2 Description of the process and lessons learnt

I present a description of the process of determining the depth and breadth of content in a step-by-step approach and the lessons learnt in that process.

#### *6.3.2.1 Step 1: Acquiring school content knowledge from reading school curriculum and textbooks*

When I was planning and deciding on the content that should be included in my teaching of population ecology, I looked at both the CAPS syllabus and the IEB syllabus. The two curricula documents outlined concepts that needed to be taught under the topic of population ecology. I had to decide on the textbook that I could refer to, to gain this content knowledge. Drawing from my experiences as a learner and as a student teacher, I decided to use the textbook by Isaac et al. (2012). I used this textbook because it was widely used in schools when I was still a learner and when I was a student-teacher. Many schools used this textbook and teachers commended it for its good explanations and activities for learners.

**My reflection and lessons learnt:** After reading the two curricular documents, I knew exactly what was done in schools on the topic of population ecology (the summary is indicated in Appendix I). Using the school textbook was refreshing in the sense that it added *flesh* to the syllabuses that I had read. That is, I gained a basic understanding of the topic added to the one gained from the school syllabuses. A lesson here is that although the curriculum documents, as the first documents to consult, can help one gain the school content, they are not explicit enough as

they do not explain the concepts in detail. Reading the school textbook develops one's basic understanding of the content for the school level.

#### *6.3.2.2 Step 2: Acquiring the university content knowledge from reading the university textbooks*

One of the aspects of practice that I have learnt about planning from the experienced teacher educators is to read the university textbooks to enrich my knowledge of content for university students. Although I consulted a variety of university textbooks, I relied more on the textbook that was prescribed for the students. I noticed that the concepts in the school syllabus were also in the university textbooks. However, the university textbooks went into details of a single concept and had ideas that were not necessarily in the school syllabus. I also found that some textbooks had representations; tables and graphs that I could use in my teaching while some had good explanations of concepts.

**My reflection and lessons learnt:** Reading the university textbooks helped me to gain content knowledge for university students. At this point, I had a solid understanding of the content that is in the university textbooks but not covered in the school syllabus. Some of the content in the school syllabuses was more understandable when I read the university content. This became one of the aspects that influenced my decisions on the content knowledge for pre-service teachers. In addition to gaining the content knowledge, I also gained some knowledge of how I can use the representations found in the textbooks as my teaching aids.

#### *6.3.2.3 Step 3: Acquiring possible student prior knowledge as one of the influencers of deciding content to teach to pre-service teachers*

Discussions with the experienced teacher educators revealed the significance of possible student prior knowledge (including misconceptions) when planning. I, however, did not get a sense of how I could access the prior knowledge besides giving students a baseline activity during the first lecture. I decided to search for relevant literature because Nyamupangedengu (2018) found that research literature is a good source of teaching ideas, including possible students' prior knowledge. Although these were not specific to population ecology, they gave me an overview of possible student prior knowledge in ecology, including misconceptions. To make sure that my choice of content builds on what the students have done in the past, I checked what possible correct

conceptions students could bring to my class. I studied the curriculum that the science division follows to get a sense of what the students covered in NS I and NS II.

**My reflection and lessons learnt:** The procedure of doing a literature search on the possible student prior knowledge was a good exercise and it helped me get a sense of what misconceptions the students may bring to lectures so that I can tailor the content and approaches such that these misconceptions are addressed. Reviewing what students have done in the previous science courses also helped to make decisions such that I can build on the prior knowledge they have. I became informed that they had covered the topic of ecosystems and interactions in the environment in NS II.

#### *6.3.2.4 Step 4: A description of how I decided on the depth and breadth of content to teach the pre-service teachers*

In the three steps above, I have precisely described what would influence the decision on the content that pre-service teachers need to learn. Using the lessons learnt as presented above, my first attempt was to revisit the table that compared the CAPS and IEB syllabuses see (Appendix I) and extract the school content and then what I considered the university content. This table is in Appendix J. At that point, I had *packaged* the content into big ideas[18]. I did this while exploring what I could teach in the first week. After the presentation of this table to my critical friends, I discussed it with one of them:

| | |
|---|---|
| **Celia:** | *I teach the same topic at my university, and I can see that most of what you have here; I also teach. I am interested in what guided your thinking and your reasoning.* |
| **My response:** | *Like, I was just thinking that this is where they need to start…to understand what characterises populations* |
| **Celia:** | *Yes, that is also where I start, what led you there? How will excluding this [population characteristics] make a difference to the content and their learning? And especially because they are teachers.* |

**My reflection and lessons learnt:** I found Celia's questions to be intriguing and helpful because she reminded me of a tool that I learnt about in my undergraduate studies. The tool is called

[18] Big ideas are statements that capture the content of science. They *package* the concepts and give an overview of the content intended for the students to learn.

Content Representation (CoRe). I revisited the tool to remind myself of what it entails. I realised that CoRe could be used as a foundation for deciding on the depth and broadness of the content that pre-service teachers need to learn. CoRe is a planning construct that researchers have used to capture teachers' reasons for the decisions they make when planning and when teaching (Loughran, Berry & Mulhall, 2012). I noticed that the preliminary decisions that I had made on the depth and breadth of the content could actually be represented by the first three prompts of the CoRe; 1) what do you intend your students to learn about this big idea and 2) why is it important for students to learn this knowledge? 3) What else do you know that you do not want your students to know yet? This suggested that the CoRe could serve as a tool for deciding on the content to teach pre-service teachers and also reveal the teacher educator's PCK. This was a lesson for me to then explore how I could use the tool to help me decide on the content.

I then constructed a CoRe under one big idea using the first three prompts as they seemed to be speaking to decisions about content to teach (See Appendix K). I again presented the CoRe to my subject expert critical friends. After a series of discussions, I came up with a list of prompts that one could consider as guidelines for determining the breadth and depth of content to be taught. I provide the list below:

1. The relevance of content to pre-service teachers
2. Pedagogical implications
3. The link to the chosen content delivery methods (e.g. if the pre-service teachers need those concepts to do a specific practical activity)
4. The value of that content to addressing misconceptions
5. The significance of a concept in completing a big idea (e.g. characteristics of populations as a big idea is not complete without the concept of dispersion)

I used the five prompts to construct the framework in Figure 6.1, which shows the *prompts* for making decisions on the content.

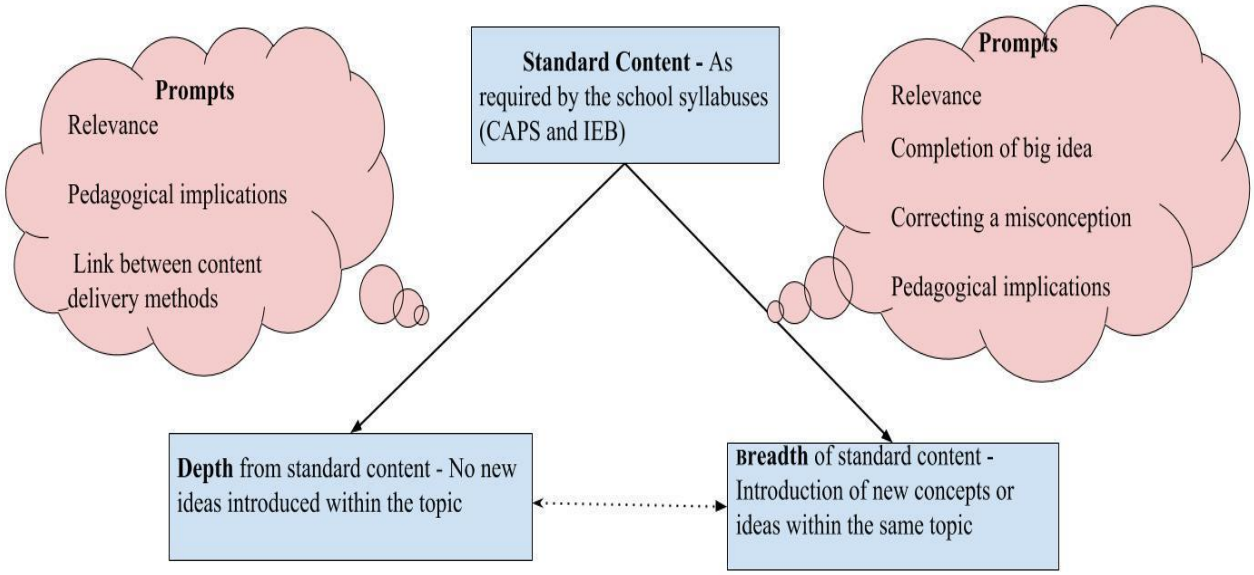



**Figure 6.1: The framework I designed to decide on the content that the pre-service teachers need to learn**

*Explanation of the framework*

The first rectangle at the top of this framework shows what I would call standard content. The standard content is the content that is given in the school syllabuses. In the South African context, the standard content would be the content that needs to be taught for that topic at the school level. This should be compulsory for a teacher educator to include and teach this content because it is the basic content that the pre-service teachers will need to teach in schools. The two bottom rectangles show the depth and breadth of the standard content. This is where the teacher educator's reasoning lies. Relevance explains how the new concept within the topic is applied to everyday lives. Completion of a big idea is based on the argument that inclusion of the concept or idea to be taught is captured in the big idea that is identified from standard content. I needed to introduce new concepts because they would help me address certain possible misconceptions as revealed by literature. Pedagogical implications explain whether the new concept or depth of the standard content is a pre-requisite to understand other ideas. This prompt has to do with curricular saliency. The last prompt to decide on the depth of a single concept or idea is how that depth helps the students to make sense of activities set-out like practical tasks. The broken line between breadth and depth shows how one can be used to explain the other – which gives more reasons for the

inclusion of those concepts. The link between depth and breadth serves as a validation of the decisions taken to either include or exclude other concepts.

The framework in Figure 6.1 as informed by the CoRe construct ultimately became a tool for me to decide on the content that the pre-service teachers needed to learn in population ecology. In Section 6.4 of this chapter, I present an example of how I used the framework to decide on the content.

### 6.3.3 The significance of exploring the specific practices about planning to teach a biology content course

In the previous section (Section 6.2), I have shown how I gained insights about planning from discussions with experienced teacher educators. I then identified one aspect of planning which I considered problematic; deciding on the content for the pre-service teachers and focused my exploration on that aspect. The exploration that involved a back and forth interactions with the subject experts helped me to formulate a framework (illustrated in Figure 6.1) that I ultimately used to decide on the content that my biology pre-service teachers should learn in the topic of population ecology (see the next section). One of the key findings in terms of the framework is that there needs to be reasoning and justification for decisions made in terms of the content. This reasoning is guided by aspects like the relevance of content for the pre-service teachers. The discussions with experienced teacher educators were a basis for this central insight in the sense that they were focused on a specific aspect of biology teaching, which is planning. Aubusson, Steele, Dinham & Brady (2007) and Feiman- Nemser (2001) indicate that learning within the professional discourses require identification of a phenomenon and sticking to its practices. I identified the issue of deciding on the content which seemed to be challenging.

## 6.4 PRESENTATION OF MY PLAN TO TEACH A BIOLOGY TOPIC

In the previous sections, I reported on the lessons learnt from discussions with experienced teacher educators and from my exploration focusing on how one can determine the depth and breadth of the content to teach to pre-service teachers. I was then clear of what planning entails and how I can plan to teach a biology topic to pre-service teachers. I used these lessons and the insights gained from the beginning of the study (as presented in chapters 4 and 5) to inform my planning. The teaching of all content courses in the Division of Science Education has three aspects, namely

lectures, practicals, and tutorials. In a week, there are two lectures (one double lecture of 100 minutes and a single lecture of 50 minutes). Tutorial sessions are one period long (50 minutes) and practical sessions are three periods long. My planning was influenced by this breakdown of face-to-face contact sessions. In this section, I present the descriptions of the steps I followed in my planning to teach the topic of population ecology to third-year pre-service teachers.

### 6.4.1 Determining the breadth and depth of the content of population ecology to teach and sequencing my lectures

In the previous section, I presented my exploration of determining the depth and breadth of the content of population ecology. I ultimately came up with a framework that I could use to guide my decisions (see Figure 6.1 above). Below I show an example of how I used the framework.

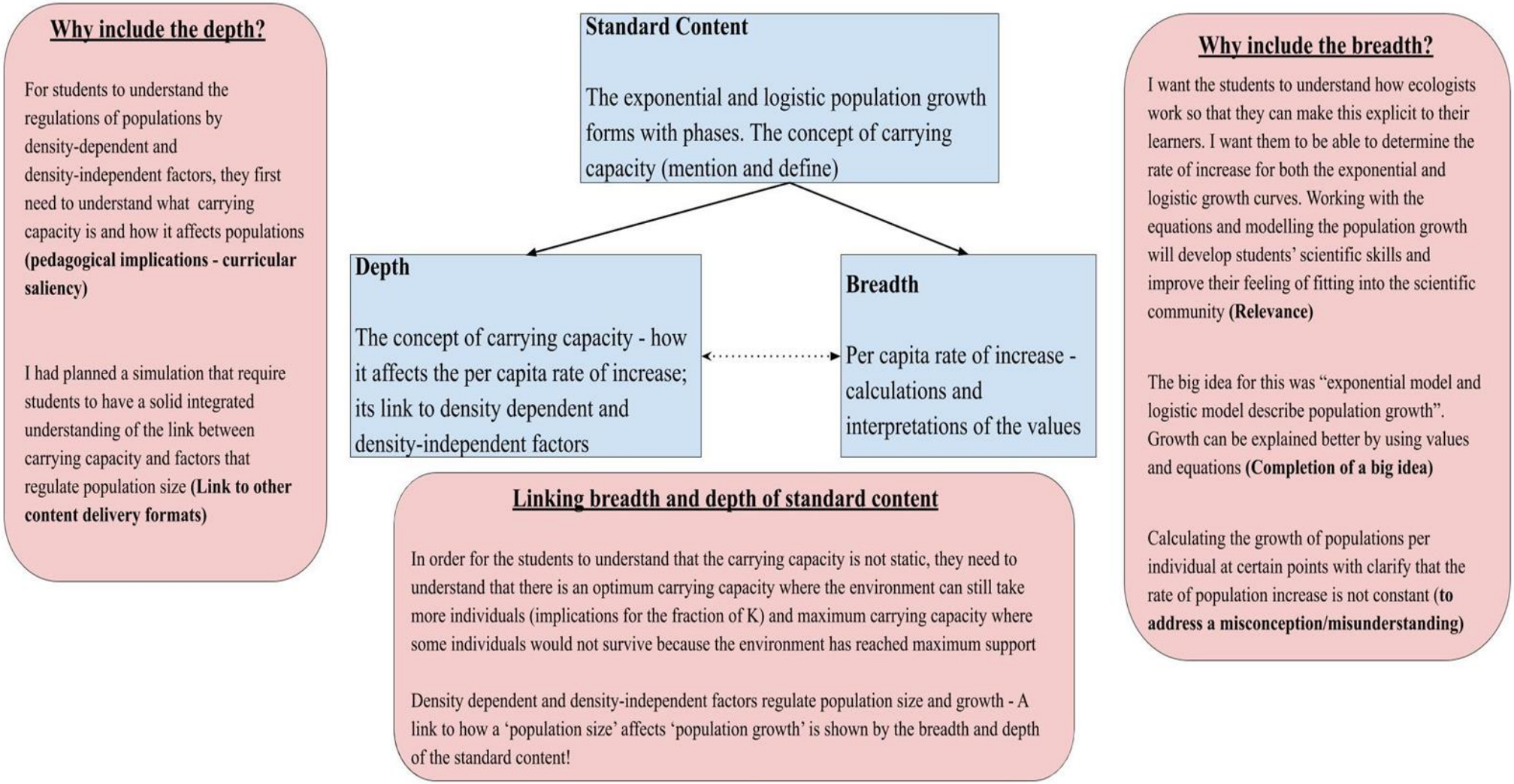



**Figure 6.2: An example of how I used the framework to think of what to teach in a single idea**

Figure 6.2 above shows an example of how I mapped the content using the framework in Figure 6.1. The standard content, which is the content from the school syllabuses, covers exponential and logistic population growth form. Carrying capacity is only for mentioning. For the pre-service teachers, I, therefore, decided to include the content on carrying capacity as the depth and calculating the rate of population growth as the breadth because of relevance and pedagogical implications as indicated in the figure.

From the teacher educators, I learnt that if the content is clear; the next step would be to sequence the content. That is, thinking about what would be covered in each lecture. After going through the process described in the previous section and the back and forth discussions with my subject experts, I ultimately had a table (Table 6.2) that shows the concepts and big ideas that would be covered in the lectures.

**Table 6-2**

**Concepts and big ideas for the topic of population ecology I taught per lecture**

| Lecture | Concepts | Big idea (s) |
|---|---|---|
| 1 | Range, Dispersion, Population size, survivorship curve, life tables | Populations exhibit three important characteristics; range, dispersion and size and growth |
| 2 | Exponential growth model, logistic growth model, per capita rate of increase, carrying capacity, biotic potential | The growth of most populations is best explained by the exponential or logistic growth model<br><br>Per capita rate of increase represents growth of populations per individual |
| 3 | Density dependent factors, density-independent factors, life histories and reproductive strategies | Density-dependent and density-independent factors regulate population growth<br><br>Survival of populations differ according to life histories and reproductive strategies |
| 4 | Mutualism, parasitism, and commensalism social interactions | Interactions in the community are classified according to whether they help, harm or have no effect on the species or populations involved |
| 5 | Population pyramids, demographic transition, population growth | The growth of the human population depends on the shape of the pyramid, political and socio-economic factors |

Table 6.2 shows how I sequenced the big ideas for every lecture. This was done after the determination and validation of the content that I wanted the pre-service teachers to learn. The sequencing of the lectures was guided by the duration of lectures (whether it is a single or a double lecture) and the amount of content that I had identified. More importantly, I also looked at whether there is progression. For example, in lecture one, the students needed to learn what population ecology is and the three characteristics of populations. The knowledge they have

acquired in lecture one would be useful in lecture two, where they learn about models of population growth.

I used this table to ultimately design a detailed programme that also shows tutorial and practical sessions (See Appendix L). In the beginning, I developed the detailed programme as just a plan to guide my students and me on what needs to be covered. In other words, it was for the students to see the progression of concepts to be taught in three weeks. This was useful for me to also see the structure of the course and to keep track of what should be done in every week. Secondly, I constructed a detailed programme to help students see when the tutorial and practical investigations were scheduled to take place.

### 6.4.2 Determining the teaching methods for lectures

As I was determining the content knowledge that pre-service teachers needed to learn, I was also thinking of the teaching methods that I wanted to use for my lectures. Below I present the teaching methods that I ultimately determined and used in my planning.

#### *6.4.2.1 PowerPoint presentations coupled with worksheets*

In Chapter 4, I have presented how a certain design of PowerPoint presentation did not work as I anticipated in terms of engaging students during my lectures. Having seen how the way I did things did not help me in maximising student engagement and giving good explanations for coherence, I decided to incorporate worksheets in my teaching because worksheets in lectures work; as I learnt from observing experienced teacher educators (insights presented in chapter 5). The decisions I took were also influenced by the kind of topic I was teaching. Figure 6.3 below shows an example of the design of PowerPoint slides that I ultimately used.

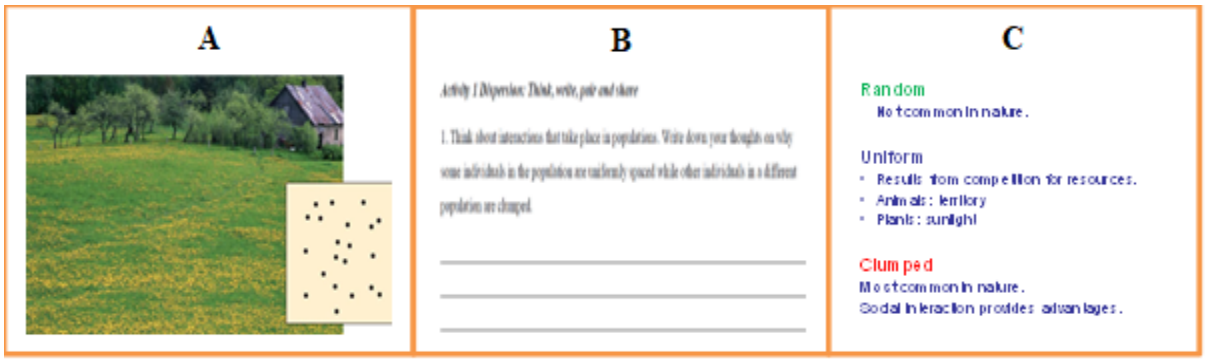



**Figure 6.3: The order of slides with worksheets incorporated**

I envisaged that the slides would serve as an aid for interaction about the concept of dispersion. In planning to enhance student involvement, I used a worksheet that had questions about dispersion for students to put their thoughts down. The questions on the worksheet had instructions such as *think, write, pair* and *share*. Slide C would not be available in the students' handout (PowerPoints slides) because it would capture the answers to B. Jane and Celia commented on my PowerPoint presentation as follow:

| | |
|---|---|
| ***Jane:*** | *You have many slides with good graphics and explanations…good thinking activities* |
| ***Celia:*** | *Your slides, they look good, students can see pictures and engage…* |

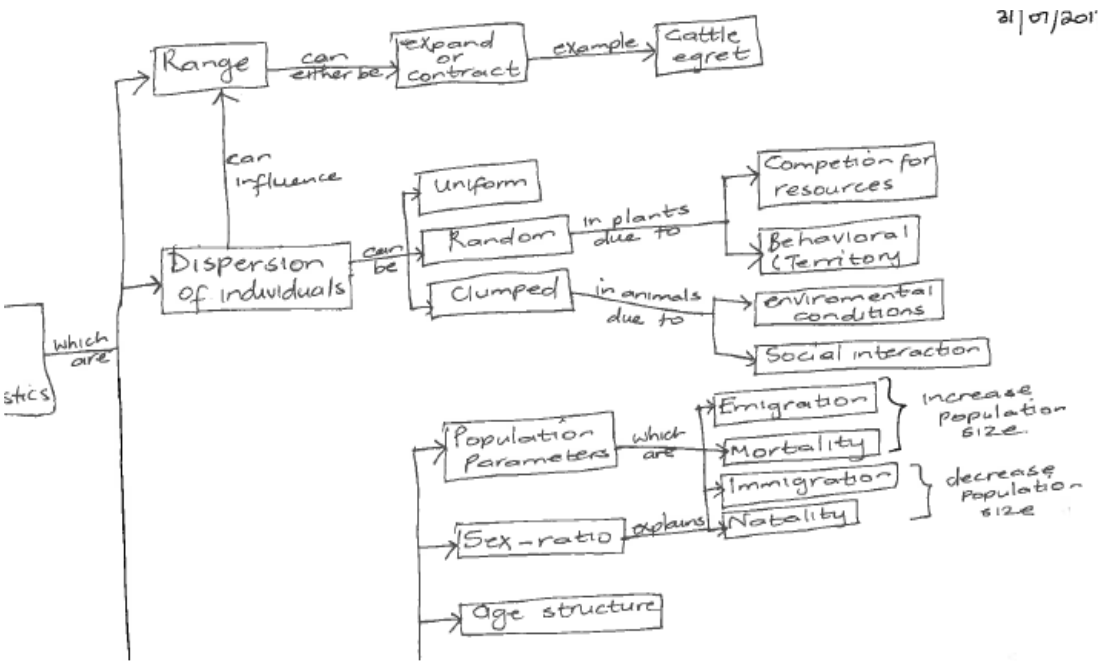
**Reflection and lessons learnt:** Jane's last comment on "good thinking activities" and Celia's comment that "students can engage" made me realise that structuring my slides in that manner could work for students to get access to the content moving from understanding what the picture depicts as a teaching and learning aid to an activity for interaction. From this, I learnt that the preparation and use of PowerPoint presentations depend on the lecturer's views about how teaching should be done. It also depends on the nature of the topic and the contextual factors. Since I valued interaction and engagement, I have gone through three attempts to prepare slides in a way that can help me in engaging the students in my lectures (see the first two attempts in Chapter 4 Section 4.4.3).

#### *6.4.2.2 My plan for opening and closing of lectures*

One of the practices of teaching I observed in the experienced teacher educators was the use of questions projected on the screen for students to answer just before beginning with the content of the lecture. I have also learnt that prior knowledge includes what the students have learnt in the previous lecture. My experiences of teaching the human ear for a week revealed my inability to conclude lectures. I, therefore, had to consider all these factors during my planning.

In addition to eliciting student prior knowledge at the beginning of the lecture, I constructed concept maps for every lecture that summarised the content. In other words, I planned and used the concept map to recap and consolidate what I have done in the previous lecture. Figure 6.4 below shows parts of the concept maps I used in the second and third lecture. I decided to construct the concept maps myself because I was the one who was going to teach the content. So, I knew what was covered in the previous lecture. This allowed me to also reflect on the content I had covered.

Lecture 1 concept map used in lecture 2




Lecture 2 concept map used in lecture 3

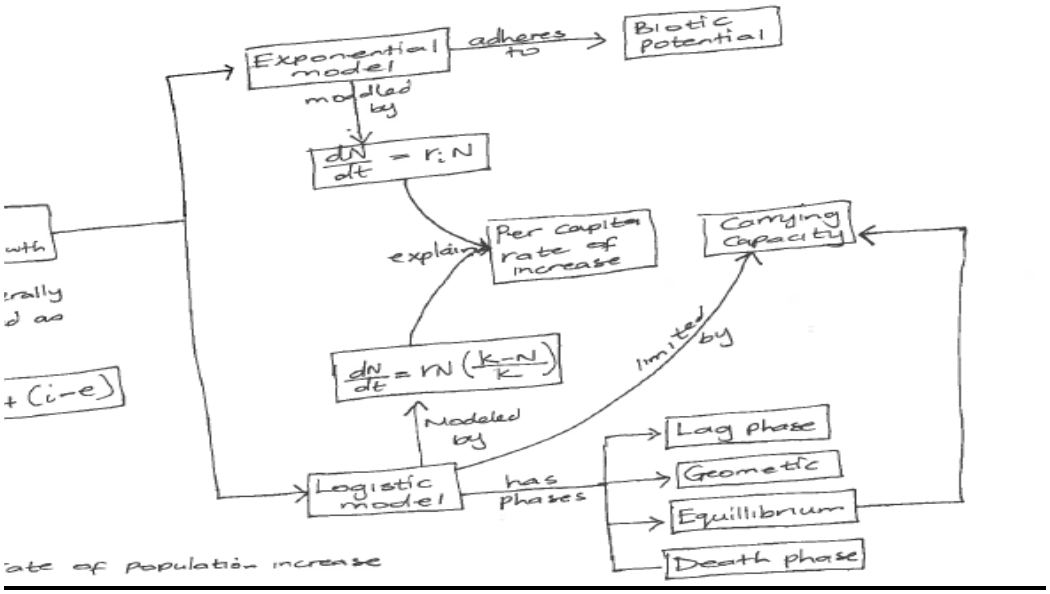



**Figure 6.4*:* Sections of concept maps constructed to use in lectures**

To conclude every lecture, I had planned to summarise what had been done in the in the lecture, I had included one slide at the end of my PowerPoint presentation about the following questions: 1) What have we covered today? 2) What will we cover in the next lecture? 3) What do you need to prepare for the next lecture?

**Nelly:** *The questions would give students some sort of a roadmap and for them to see how the course progress.*

**My reflection:** I found the concept maps to help consolidate the content that I would have covered in the previous lecture with me, hoping that this would be the case for the students. Nelly's confirmation that using the questions as a guideline could indeed help students to have an idea of what is to come. I envisaged that in addition to the detailed programme that I planned to give students, the emphasis of the last slide in my PowerPoint presentation would ensure the continuity and progression of my teaching.

#### *6.4.2.3 The use of analogies as a teaching approach*

I had learnt from observing the experienced teacher educators that students tend to make meaning of science concepts when they can formulate mental images. For example, Mariam used narrative stages, where students could visualise the functions of different parts of the brain. I, therefore, planned to use analogies in my teaching. Below I present an example of the analogy used as planned and the insights gained.

**How I chose an analogy to explain the concept of dispersion:** As I was thinking about what I can use for students to understand the idea of dispersion, I thought of an analogy. The analogy about how certain arrangements and behaviour of a group of people in one room would explain dispersion. In my planning notes given to the critical friends, it was indicated, but I did not have pedagogical reasons for why I wanted to use that specific analogy. A comment filled with questions from a critical friend prompted me to revisit my reasoning for choosing that specific analogy for this particular concept. Nelly only made this comment after I taught the concept.

**Nelly:** *I liked that analogy you want to use on dispersion. Where did you get it, and how did you choose it? Why did you decide to use that specific one? There is surely something about it that made you choose it. It is just like thinking of representations to use*

**My response:** *I got it from some document on the internet…it just made sense to me.*

**Nelly** *What made the analogy plausible to you? What do you think made it to make sense to you?*

**My reflection and lessons learnt:** The fact that Nelly liked the analogy was a lesson for me about the choice and use of analogies in biology lectures. I noticed that I had not given my choice of the analogy and my thinking about the analogy enough thought. I had decided to use

it because it made sense to me and that I understood it. The first key aspect was about the correlation between the analogy or representation and the science concept to be explained. The second aspect was that the analogy related to the students as they could link it to what they observe and do in their everyday lives. The literature on cognition and science advocating the use of analogies has long revealed that the issue of mapping when using analogies is important. Gentner's (1983) and Glynn and Takahashi's (1998) indicated that the analogy should map to the science concepts taught in the sense that there is a base domain (analogy) and the target domain (science concept). The base, in this case, would be the students in the classroom and the target would be the dispersion of individuals in a population. A lesson from this is that when choosing an analogy, I need to make sure that it portrays the science content that is targeted.

Just like the science teachers who advocated the significance of analogies when teaching difficult and sometimes confusing science concepts (Cherif, Siuda, Roze, Movahedzadeh & Gialamas, 2015), analogies can also be used in biology teaching to teach pre-service teachers. I envisaged that the use of the analogy would help students understand the concept of dispersion.

### 6.4.3 Determining approaches for tutorial activities

As indicated in the introduction, the teaching of science content courses at WSoE also involves tutorials where students are allocated to groups of less than thirty students. The students then have tutors to facilitate the interactions in these tutorials. I, therefore, had to plan the tutorial activities (see Appendix M). Below I present what I planned and the lessons learnt thereof.

#### *6.4.3.1 Giving students relevant activities to their everyday lives*

The insights gained from experienced teacher educators is that some pedagogies are topic-specific. In my planning, I considered this, especially the fact that the topic of population ecology, with its particular focus on the human dynamics, is a social issue because human population dynamics raise concerns that are about the future of the world in which we live. It was, therefore, necessary for the pre-service teachers to be aware of some of the concepts of the human population that perpetuate this controversy. In a tutorial activity, I wanted students to engage in a debate about whether an increase in the human population is a threat to the environment. I asked students to prepare a presentation in groups and present it to the rest of the class for feedback and questions. I formulated *scenarios* that captured the issues related to

the human population. Most of these scenarios came from the monograph written by Peron (1995) which talks about the myth of human overpopulation. I constructed a rubric for assessing the presentations (see Appendix M).

I presented the activity to the critical friends and asked them to specifically comment on the authenticity of the activity and if they thought that this activity would be good for the students to do.

> **Celia:** *I once gave my students something similar in the past two years, and they enjoyed it; they drew from their experiences and beliefs*
> **Jane** *You just have to be careful that it does not end up as a war. Well, in your context you might not experience a lot of problems, but they will relate because I can also see myself in it as I am reading it*

***My reflection:*** Jane and Celia confirmed that the activity is authentic to students beyond the content they would learn in the lectures. Besides this, I learnt a new lesson about designing activities that would apply to students' everyday lives. That is, sometimes, these activities tap into their beliefs and might ignite their emotions and feelings. At the end of my planning, I had learnt that I needed to be aware of such factors. One way of controlling the students' emotions and beliefs is clearly explaining the objectives of the activity in relation to the biology content that needs to be learnt.

#### *6.4.3.2 Phrasing of questions in the tutorial activity to trigger interactions*

I have indicated in Chapter 4 that the lesson I learnt about tutorials is that it does not matter if students are given the task before the actual session or during the session. What matters are the questions included in the activity and how they are phrased. I gave students the tutorial tasks before the session so that they can prepare their questions. For the first tutorial. I wanted students to consolidate their understanding of the concepts of density, demographics, and dispersion. For example, the fifth question in tutorial 1 was "The following shows a reproductive table for the Belding's ground squirrels. Interpret the table as much as possible*"* and the third question was *"*Draw the most likely survivorship curve for a particular fish species where each female produces millions of eggs per year. Give a brief explanation for your choice of the survivorship curve". I presented gave the tutorial activities to my critical friends:

> **Jane**: *Interpret the table as much as possible. Explain what trends the data in the table shows. This is a good question for students to interact, but how are you going to explain these numbers to students? You may need to*

*spend some time in the lecture talking about reproductive tables because a student would argue that you cannot have 1.58 offspring.*

**Audrey** *Good tutorial questions, students may need to prepare for them and do some research*

**My reflection and lessons learnt***:* Jane and Audrey confirmed that the way I have constructed the tutorial questions would require the students to research before the tutorial. Jane, on the other hand, helped me to construct the tutorial questions to make them clearer and understandable to students. Jane's correction of my questioning made me realise how phrasing can confuse students. From Jane's rephrasing of the question, I see the word "trends" as significant as it captures what I want students to observe, particularly what happened to the reproduction of these organisms as the age group increases. As a result, I have learnt, in addition to giving students questions require discussion, descriptions, and explanation; to isolate and highlight keywords to my questions so that students can have a better understanding of what they need to focus on for their understanding. I envisaged that these kinds of questions would help students to discuss the questions in the tutorial sessions

After reading Jane's comment on the complexity of the table that was given to students to refer to, I went back to my lecture slides and my preparation notes to see how I planned to explain the reproductive table in my lecture. What I found is that there was nowhere in the lecture where I explicitly talk about reproductive tables. Instead, I included a life table. I then included this to explicitly teach reproductive tables for the students to discuss effectively in the tutorial sessions. I learnt the importance of aligning my teaching and questioning in the activities. I then changed the question to be about life tables and not reproductive tables with links to survivorship curves.

### 6.4.4 Determining practical activities

In my planning, I had to think of the practical activities that students could do for population ecology. Below, I present the two practicals that I ultimately gave to students. For the complete planned and administered practical activities, see Appendix O.

#### *6.4.4.1 Adapting a practical activity from the school textbook*

In response to my experience as an undergraduate student of teacher educators practising what they preach, I wanted to design tasks that are authentic and tasks that the pre-service teachers can also use when they go to do their teaching. I have learnt from the observations of teacher educators that one of the good ways to model practice is through "doing what you want your

learners to do when they go to teach". I chose to give students an investigation where they needed to use objects to model the population size. I took the practical exercise from the school textbook. Students would not just do the investigation as pre-service teachers but to also pick up pedagogical ideas from doing the practical. Also, most schools in South Africa are disadvantaged such that they may not have resources to do specific investigations in population ecology. I wanted to prepare the pre-service teachers for that. The resources for this practical investigation would be accessible to most schools. These resources include sugar beans, sand, and any container. One pedagogical question that I asked students in the investigation was: "Would you do this investigation with your learners? Why? If your answer is no, what other investigation would you use?" With these questions, I wanted to allow students to imagine their future context and start thinking about aspects of practical exercises in LS that needed to be done when they are teachers. During the face-to-face discussion with my critical friends, Jane said:

> **Jane:** *This is a good investigation; we also do it in schools…it will definitely be useful to them*

**My reflection and lessons learnt:** Jane's comment confirmed the relevance of the investigation to my students. The relevance lies in the fact that the pre-service teachers would learn the skills and how they would administer the practical in their contexts when they are teaching. This experience teaches me that pre-service teachers need to be taught and given tasks that are relevant to them, and I understand relevance as things that they could use in their future contexts. According to Nyamupangedengu and Lelliott (2016), the act of practising all aspects of teaching, including the materials given to students counts as modelling practice. I envisaged that the pre-service teachers would also find it relevant

#### *6.4.4.2 Adapting practical activity that involves simulations*

In the third week, I wanted students to investigate factors that affect population growth using computer simulations. I got the practical online and adapted it. The practical required students to use simulations to investigate the sustainability of a fish population. I chose this kind of investigation because it is not easy to show population dynamics. This simulation traces the change in the growth of a species due to certain density-dependent and density-independent factors. The authenticity of the simulation lies in the fact that it uses a real-life example (fish). Furthermore, students can change several factors and discuss their influence on the fish population. This is why I wanted students to work in pairs – to allow an argumentative session when they intentionally predict the outcome.

### 6.4.5 The significance of one's plan for teaching pre-service teachers

In this section, I have presented an overview of my plan for teaching the topic of population ecology to the pre-service teachers. The main point about this overview is that it draws from the insights that I have gained from the beginning of the study. In other words, what I have gained from reflecting on my experiences, observing the experienced teacher educators and interviewing them formed a foundation for my planning to teach the topic of population ecology. By the time I was planning to teach the topic of population ecology, I had an idea of what teaching biology to pre-service teachers had meant. The exploration endeavour as a means to learn how to teach biology to pre-service teachers, greatly influenced how I constructed my practice and identity as a novice biology teacher educator. Although I drew from all the insights gained to plan, there were instances where I thought certain teaching practices would not work. For example, I had to change the way I designed my PowerPoint slides to suit the topic of population ecology. This meant for me that I was beginning to construct my professional identity (Swennen et al., 2010). Despite the observations of experienced teacher educators, I saw myself as a new person who is neither a reproduction of the experienced teacher educators. As such, I had to exercise my professional judgement when planning to look at my topic and other contextual factors. The idea of making these decisions began during the exploration phase presented in Section 6.3 of this chapter.

According to Cooper (2019), teacher educators who make professional judgements when teaching, develop their practical wisdom through reflecting on the experiences of what they do. Practical wisdom is the capacity of a practitioner to make informed decisions, involving professional judgements, about practice in the absence of a formal set knowledge (Lunenberg & Korthagen, 2009). As Furman (2016) states, it is about "respond[ing] thoughtfully to complex circumstances…drawing on skills and prior knowledge" (Furman, p. 140). In making professional judgements based on experiences and drawing from theory, one develops this wisdom ultimately their identity that manifest in how they act and deal with situations. In particular, practical wisdom has to do with teaching as an "art"; in its complex nature and not a "science" with a specific format for doing things (Kinsella &Pitman, 2012). The skill of making professional judgements does not only inform one's practice but also leads to one's re-imagination and reconstruction of future practices that develop over time—as such, engaging in the actual planning for a prolonged period to teach for three weeks helped me develop this kind of practical wisdom.

## 6.5 CONCLUDING REMARKS

The main contribution of this chapter is how one can learn about planning to teach pre-service teachers through specific ways. This chapter was about planning to teach biology to pre-service teachers. In the second section of the chapter, I presented insights gained from having formal discussions with experienced teacher educators. From these insights, I identified one practice that was unclear to me; determining the depth of content that the pre-service teachers need to learn. I then explored this aspect in my planning, and the insights are presented in Section 6.3 of this chapter. In section 6.4, I presented an overview of my plan that I ultimately executed by teaching the topic of population ecology to the third year biology pre-service teachers. The key insight in this chapter is that one can learn about planning to teach biology from having focused discussions with experienced teacher educators and focusing on the specific aspects of planning.

A study that was done by Nyamupangedengu and Mandikonza (2018) showed that reflecting on students' experiences of lectures can be an effective methodological approach for identifying and understanding effective practices for preparing pre-service teachers. Therefore, in this study, motivated by this insight from Nyamupangedengu and Mandikonza, although I taught and recorded my teaching, I decided not to analyse my teaching transcripts. Instead, I decided to gauge the effectiveness of my teaching by gathering feedback from students through interviews. In the following chapter (Chapter 7), I present what the students said about my teaching and the lessons thereof.

# CHAPTER 7: LOOKING BACK AT MY LEARNING THROUGH THE LENS OF STUDENTS' FEEDBACK

## 7.1 INTRODUCTION

The previous chapter was about searching for the principles of planning, where I also presented an overview of what I had planned to teach the pre-service teachers. I taught the topic of population ecology for three weeks and recorded my teaching. Instead of analysing my teaching, I sought feedback from the students about their experiences of my teaching because a study done by Nyamupangedengu and Mandikonza (2018) showed that reflecting on student's feedback can be a good methodological approach to learning about teaching pre-service teachers. I wanted to assess how my planned teaching came across to my students. This chapter, therefore, focuses on my reflections on student feedback on my teaching. I begin the chapter by describing the data collected and how it was analysed. The insights are organised in themes. I also use excerpts from my teaching as evidence to support what I am drawing from the students' feedback. I then discuss the significance of using student feedback to learn to teach biology. This chapter addresses the fourth research question: What knowledge about my teaching do I gain from student feedback?

## 7.2 DATA COLLECTION AND ANALYSIS

The data for this chapter was in the form of transcripts from students' interviews, as described in Chapter 3 Section 3.4.5. I had three transcripts from the focus group interviews. The analysis of the interview transcripts was mainly deductive in the sense that I was looking for how students experienced how I taught in lectures and how they experienced the practical and tutorial activities planned and administered. I went into the data with pre-determined codes and categories from the objective of this chapter and literature (Hatch, 2002). I was, however, open to new codes. Therefore, the analysis took both the deductive and inductive approach. The main purpose of this study was to investigate how I learn to teach biology to pre-service teachers, and the main objective of this chapter is to show the extent to which this learning occurred using student feedback on my teaching as a lens and the knowledge of teaching I gain from this. My teaching was characterised by what I had planned and what happened in the lectures, tutorial, and practical sessions. Below, I describe how the transcripts were coded deductively and inductively.

**Step 1:** Development of a typology as guided by the objective of this chapter – Since the analysis of the interviews was mainly deductive, the first step was to develop the typology that describes students' experiences in the three formats of content delivery methods. Table 7.1 shows this typology with possible codes. Some of these codes also came from literature about planning and teaching biology to pre-service teachers (Nyamupangedengu & Mandikonza, 2018).

**Table 7-1**

**Examples of pre-determined codes for student interview transcripts**

| Lenses | Codes |
|---|---|
| Experiences of lectures | Level of content<br>Questioning<br>Teaching approach<br>Linking of concepts<br>Content application and relevance<br>Messages about teaching<br>Assessment<br>Instructional materials (e.g. PowerPoints and worksheets)<br>Lecturer's conduct (e.g. showing care)<br>Use of examples<br>Engagement<br>Student prior knowledge<br>Lecture pacing<br>Sequencing of concepts<br>Lecturer evaluation |
| Experiences of tutorial activities | Nature of tutorial questions<br>Importance of tutors<br>Conduct of tutors<br>Role of participation |
| Experiences of practical activities | Practical resources<br>Practical manual<br>Technicians<br>Role of participation<br>Practical and investigative skills<br>Field-work |

The development of this typology was influenced by what I had planned for my teaching. It is important to note that although the codes are separated in the table according to the content delivery methods, the codes were possibly applicable across what I termed the *lenses*. For example, the codes; importance, and conduct of tutors as used to code experiences of tutorial activities; would also apply for practical activities.

**Step 2: Familiarising myself with the data** – I had data in the form of transcripts and audio recordings. I read through all three interview transcripts at least three times while listening to

the audio recordings to double-check if I have missed anything from the transcripts when transcribing. There was no coding at this point, although I got a sense of new emerging codes from each interview transcript. Reading the transcripts was accompanied by my reflections with initial interpretations of what the students were saying.

**Step 3: Coding the transcripts** - I then attempted to deductively code the first transcript using the pre-determined typology in Table 7.1 above. I could code most of the students' utterances using this typology because a lot of what students commented on was about the lectures, tutorials, and practical activities. However, not all the pre-determined codes were used. Appendix O shows the final codes that were used to code the transcripts. There were, however, some utterances that could not fit into the typology but were still significant for my learning, leading me to code inductively as indicated earlier. I then noted down these utterances and codes. Table 7.2 shows part of the first coded transcript. For each coded excerpt of the student's utterance, I indicated the initial question that was asked by the interviewer even though the student would have been responding to a probe or an utterance of another student.

**Table 7-2**

**Coded students' utterances from transcript 1 of students' interviews**

| **Student Ponelo:** |
|---|
| **Question asked:** Describe the LS population ecology content lecture session |
| like…raise my curiosity you know, because ***(student motivation)*** that's what I'm saying that he was so, so factual, like he would tell you this is it, this is what it is, this is how it happens, you know that's it, ***(teaching approach)*** You, you did not make me question things in a way. So, what are we talking about? Am I gonna ask you what population ecology is when you've already explained, (***gap in my teaching approach – content application***) You know? So, that's, that's why I think you were also talking about relational understanding, like I couldn't relate it, maybe sometimes I did, to whatever that I see every day, ***(content application and relevance)***. I think uhmm… the units of formulae, I didn't know that there were formulae in biology, like to collect data and all of that, ***(student gap in knowledge)*** I last did that in mathematics, so, to learn that in LS as well in population ecology as a whole, there are formulae, to collect data and all of that, (***link to other subjects***) that was quite interesting…***(student motivation)*** |
| **Student Lebo:** |
| **Question asked:** What sorts of content and skills have you encountered so far in the population ecology course? |
| I would have loved if he could've method-class, right? ***(student desire)***. The methodology where he can prac me on how to teach this ecology in a meaningful way that you tap critical-thinking, tap my metacognitive and ***(objective of student desire)*** in terms of content, in terms of the content, preciously I've taught population ecology I've never came across equations especially when he did exponential models, logistic models, ***(student gap in knowledge)*** I did not know there were equations that we could use to explain, ***(student gap knowledge)*** |
| **Student Pearl:** |
| **Question asked:** What sorts of content and skills have you encountered so far in the population ecology course? |

| |
|---|
| Most of the things, he did towards the end, because he even had to go back I think the first lecture, when he had to do the formulas and all of that, like re-do them, so, if he had got…gotten that right in the first lecture, ***(critique of teaching approach)*** the rest of the things I would've been able to do on my own. ***(student learning approach)*** So, that's why I'm saying, like try and make sure that we get what you're saying first ***(critique teaching approach)*** and then the rest you find that you don't even have to lecture, ***(student learning approach)*** like it's just us having these questions now, how did, how does this formula come into play ***(linking of concepts),*** why is it important like the exponential model of growth ***(content application).*** Like why are doing it, I still don't know even now, so, ***(gap in my teaching approach-content application)*** that's why I'm saying like try to relate this thing to things that we can understand ***(gap in my teaching approach-content application/content relevance)*** |
| **Student Ponelo:** |
| **Question asked:** What messages about teaching and learning did you understand from the population ecology course? |
| We wrote a test yesterday and the questioning was challenging, ***(Quality of test questions – challenging)*** it was horrible because we're used to the standard that argh ***(level of content)*** it's just content, you just read through with what you're, and then comes shocker you know? ***(student learning approach)***. The questions are on another level, (***level of questioning)*** but the presentation of the content gave us the impression that this is how he gonna ask questions. ***(alignment of level of content and test questioning)*** Questions, and that was a way to man up coz now I'm scared of the exam. The exam I'm scared coz ***(student learning goal)*** especially multiple choice, I felt like it was only higher ordered questioning coz ***(level of questioning)***. And it was that…and then in the lecture he gave us the impression that, you know the questions that he asked in the lecture they were quite straight forward, ***(impressions given about test questioning)*** now he gives us another impression, when you got to the test, all the questions like in the lecture seemed like open-ended ***(quality of test questions)*** |
| **Student Teba:** |
| **Question asked:** To what extent would you say you have enjoyed the population ecology course so far? |
| The course was fine; I don't want to lie but I just want to say something about his tricks ***(lecturer evaluation).*** I am one of the students, *be ke se ka emisha letsogo mara a nkgetha* (my hand was not up but he just picked me up) ***(teaching approach, questioning)*** to answer. I did not like that because he caught me off guard. I really enjoyed working on the worksheet ***(instructional material),*** yah, so, it was just that when you worked on something (***student's desire)***, you know for sure that you can answer. And I wouldn't do that to my learners unless I have given them something to do and time to think ***(pedagogical messaged portrayed)*** |

After coding the first transcript, I applied the typology to the other two transcripts, and I was still open for new codes. As I was coding, the pre-determined codes illustrated in Table 7.1 were refined. For example, although some students' utterances were about questioning, the code "quality of questioning" captured the essence of the utterance. I, therefore, had to go back to the first transcript and refine the codes (see Appendix O for a final list of codes and descriptions). The new codes that emerged as a result of the inductive analysis approach are mostly about students describing themselves and their desires. Some of these codes are listed below (see Appendix O for descriptions of these codes):

- Student's desires
- Student's learning goal
- Student motivation
- Objective of student's desire
- Student's learning approach

- Student's learning objectives
- Usage of learning management system
- Gap in my teaching approaches

**Step 4: Finding patterns and relationships** – After coding the three transcripts and refining the codes, I looked at the patterns amongst what the students were saying about my teaching to develop themes that capture the essence of students' experiences of my teaching. These themes are presented below:

1. The nature and level of content chosen versus the teaching approaches
2. The use of worksheets as a teaching and learning approach
3. The design of my PowerPoint presentations
4. Use of analogies and examples in biology teaching
5. Making links between lectures and tutorial and practical activities
6. Alignment of the content taught and how it was taught and summative assessment
7. The discussions approach during tutorial sessions consolidates students' understanding of the content covered in the lecture
8. Authentic practical activities help students to imagine their future contexts
9. Students learn about teaching from pedagogical practices
10. The use of a learning management system in teaching
11. The role of lecturer's conduct on pre-service teachers' learning of content

## 7.3 MY REFLECTIONS AND INSIGHTS GAINED FROM STUDENTS' EXPERIENCES OF MY TEACHING

In the previous section, I described how the interview transcripts were analysed and listed the themes that emerged from this analysis. In this section, I present the insights gained from the students' experiences of my teaching. In presenting the insights, I also confirm, disconfirm, and/or extend the lessons that I had accumulated throughout the study and the lessons that informed my planning and teaching. For each theme, I present examples of the actual students' utterances, my interpretation then my reflection and lessons learnt. Where the theme pertains to specific practices that happened in the lecture, I show excerpts from the teaching transcripts to support the students' experiences and my reflections on my teaching.

### 7.3.1 The nature and level of content chosen versus the teaching approaches

In the previous chapter, I described how I determined the content of population ecology that the pre-service teachers had to learn. The analysis of students' feedback showed that the content that I chose to teach under population ecology was appropriate and relevant for biology pre-service teachers. The students said the following:

**Lebo:** *The content was okay for us at university; he did not just teach us what we have to teach in the school, it made me more inquisitive*

**Julie** *Other things we did not pay attention to but now I know that there are lots of factors that affect populations, the information that he taught, now I look at nature in a different way*

**Hilda** *We definitely now look at nature in a different way compared to how we looked before. I can now have discussions with my friend and people who like such things, about the environment*

The fact that Lebo acknowledged that the content taught went beyond the school content is evidence of the content being at the right level for them as pre-service teachers and as university students. The student's assumption or view is that what they learn at the university level should be more advanced than what they will teach in schools. That means the level of the content was justified for them as third-year university students of teaching. Furthermore, the content made her "more inquisitive" in that she wanted to know more as is expected of any other university student. Julie and Hilda expressed the relevance aspect of the content taught. The content seems to have shifted the students' thinking in how they perceive nature and how they would interact with what they see in their everyday lives. In addition, Hilda's last comment illustrates that when the content is taught, she thinks of the informative discussions that she can hold with people about what happens in nature. In other words, she reflects on the content taught and asks herself the question of how this content can be beneficial to her during meaningful discussions with other people.

**My reflection and lessons learnt:** The students' experiences confirmed that the framework I used to decide on the content could be a useful tool for biology teacher educators to decide on the content (see Figure 6.1 in Chapter 6). The content was at a suitable level because it bridged the gap they had in prior knowledge. The fact that most students said they did not know that there are calculations in population ecology (or biology) confirms that the content chosen was useful because they learnt new things. The other key aspect was the relevance of the content chosen to the pre-service teachers. The issue of the relevance of the content that we teach as biology teacher educators can be put in the context that we are teaching students of higher

education. The focus should primarily be on getting them to learn and understand the subject matter knowledge and the knowledge that they will need to carry their work, that is, the work of teaching learners.

As a biology teacher educator, I am teaching students who are members of the broader society; students who carry certain social assumptions, responsibilities, beliefs, values, and attitudes that at times are linked to the content that I teach them. Hence, when the content is taught, the students tend to continuously reflect on those social issues as they go into different states of mind beyond just being the students at a university. In other words, they change their identities as they are listening to the teacher educator. Nyamupangedengu and Mandikonza (2018) argue that being aware of and responding to students' possible identities can fulfil the purpose of teaching biology to pre-service teachers. The students' utterances have confirmed for me that the choice of content – based on the prompts illustrated in Figure 6.1 in the previous chapter – can respond to these students' multiple identities. That is choosing the content that is at the right level for them as university students, content that they will teach in schools and content that also links to their everyday lives.

Although the students confirmed the level and relevance of the content to them as pre-service teachers and individuals who exist in the society, they were of the opinion that the approaches used in the lectures did not explicitly and accurately bring out that relevance.

**Ponelo:** *That's what I'm saying that he was so, so factual, like he would tell you this is it, this is what it is, this is how it happens…like I said before, he could have used more strategies for us to see how it applies but sometimes he did*

**Pearl:** *Like why are doing it, I still don't know even now, so, that's why I'm saying like try to relate this thing to things that we can understand*

Ponelo and Pearl raised an important aspect by critiquing the teaching approaches I used. Ponelo is of the opinion that although some the teaching approaches I used related to what is happening in nature, they were not enough. Similarly, Pearl commented that relating the content to what is happening in nature could have enhanced her understanding.

**My reflections and lessons learnt:** What the students have raised showed a gap in my pedagogical knowledge. This means the selection of the "relevant" content that the pre-service teachers needed to learn was not enough. I need to also critically find powerful ways of teaching that content such that the relevance and applicability in students' everyday lives is revealed. Even though Hilda commented that she now looks at nature in a different way because of the

content she received, it might not be the case with other students. Hence, the need for me to explicitly reveal this applicability of content by using teaching approaches that connect the content to students' everyday lives.

### 7.3.2 The use of worksheets as a teaching and learning approach.

In Chapter 5, I learnt through observing experienced teacher educators that the use of worksheets can promote interaction. I used this knowledge to then plan my teaching such that I incorporate worksheets for my students to do activities (see Chapter 6 Section 6.4). Students' feedback confirmed my earlier observations that the use of worksheets promotes students' engagement with content during lectures. My students commented on how the use of worksheets was effective in helping them to engage with the content.

| | |
|---|---|
| **Ponelo:** | *Like he'd say something or bring into the topic then write an activity, say something, write an activity. That was learner engagement, like teacher-learner engagement that I wanted in a lecture* |
| **Hilda:** | *The interactions, that is one thing that I enjoy about LS lectures when we are given time to talk because that is when most learning happens, I promise you, look at the calculations, I actually understood then when I did them with a partner on a worksheet* |
| **Fatima** | *I really liked using those worksheets, like in every lecture he would have a worksheet with questions and that would be the time where you work with someone* |
| **Leslie** | *I think the most interactive part was the worksheet almost after every two or three slides* |

The students raised a very important aspect of teaching – the issue of interaction and use of instructional materials in lectures. Ponelo is specific on what he expected and longed for in every lecture, that is, lecturer-student engagement. To him, the lectures were interactive enough such that he could engage with the content and the lecturer himself. Hilda confirms that she learnt a lot more when she engaged with peers in class, which again signifies the importance of student-student interaction. Fatima and Leslie allude to the comments by other students that using the worksheets in the lectures was an effective approach to promote interaction.

**My reflection and lessons learnt:** Even though I used worksheets in lectures when I was planning my teaching, I was not sure how students would perceive the instructional materials (e.g. the use of worksheets in lectures) and the approaches (e.g. discussion teaching approach) that I used. I, however, still made a decision to use the worksheets. The main insight here is that worksheets work in biology lectures as instructional materials to promote interaction as I envisaged. However, what seemed to be the main highlight was using the worksheet coupled

with the PowerPoint presentation. This is evident when Ponelo says "he'd say something or bring into the topic then write an activity*"* and Leslie said: *"*almost after every two or three slides*"*. Instead of giving the students the whole activity in the worksheet in the middle or at the end of the lecture as I learnt from experienced teacher educators, I had decided to break down the activities in a worksheet such that I teach using the slides then students do a short activity. I did this in every lecture. I learnt that this is a powerful strategy to keep the students engaged with the content. This confirms the lessons learnt from teacher educators' observations and my teaching about the value of interaction in lectures and further extended the view that my decision of letting students complete the worksheet in parts moved the students from mere interaction to meaningful engagement with the content.

Although the use of worksheets is not a sustainable approach, especially if there are many students in a classroom, other activities that do not require printed worksheets may be used. The key idea here is to have students doing a range of meaningful activities in the lectures that foster engagement.

### 7.3.3 The design of my PowerPoint presentations

In the previous chapters, I have presented how I came to learn about the construction of PowerPoint presentations as the main instructional material used in lectures. As described in Chapter 6 Section 6.4 my PowerPoint presentations for teaching the topic of population ecology were carefully designed to display more diagrams and limit text while incorporating the worksheet. The students in their feedback confirmed that the design of the slides was beneficial to them, and it encouraged them to come to class. In addition to the PowerPoint presentation helping students to engage, the students highlighted how they were motivated to do research and read their prescribed textbook.

> **David:** *For me, the PowerPoint he used worked and pushed me to read for myself*
> **Teba:** *The slides were different from what we are used to in other lectures, he did something similar to when he taught us with Dr Nyamupa, and that made me to read the textbook*
> **Drake:** *He encouraged us to read the textbook because the slides were not detailed*

The students' use of words such as "pushed" and "encouraged" is a sign that they were motivated by how the slides were designed and used in the lectures. Teba was explicit in the sense that the structure of the PowerPoint presentations made him read the textbook from which

it can be assumed that she does not necessarily read when the slides are populated with texts that they can use as notes.

**My reflection and lessons learnt:** The key aspect of practice that is confirmed here is that certain construction of slides in PowerPoint presentations motivates students to learn while others do not. Furthermore, it dictates to students how they should learn, which in turn influences the kind of knowledge that they acquire. It is important to carefully think of the purpose of the instructional materials in lectures. My purpose was to enhance students' learning, for interaction, and my reference when teaching. The slides, however, served more than the purpose I had thought about – motivating students to study more. If I had a lot of text on the slides, the students would have used the slides only to prepare for assessments like tests, and this would have given them a shallow understanding of the biology concepts. Since the slides were not enough to prepare for the tests, they had to read the prescribed textbook, and this elevated their understanding of the concepts. My engagement in the process of learning to construct a PowerPoint presentation ultimately made a difference in the student's learning and added to my understanding of how I, as a biology teacher educator can develop appropriate and useful instructional materials.

### 7.3.4 Use of analogies and examples in biology teaching

In the previous chapter, I indicated how I planned to use an analogy to explain the concept of dispersion. I have used the analogy in my first lecture, and students seem to have grasped the idea of dispersion from using the analogy. Two students said the following:

> **Leslie:** *You know; in terms of the examples, it was one example for the whole thing, and that doesn't help you because, for me, I understand when there are examples like he gave examples of clumped, even the analogy made things simple*
> **Fatima:** *The example he gave of people in the room, yes, that was good, he showed us the dispersions*

Leslie and Fatima appreciated the analogy that I used to explain the concept of dispersion as this analogy helped them to make sense of the content. Fatima indicated that I showed the dispersions by drawing "things" on the board. Figure 7.1 below shows my exact explanation during the lecture and what I drew on the board to aid my explanations.

1. The best way to visualise dispersion is when we...let's say we are in this room and we are in a meeting; if I know him and her *(randomly points at students)* and somebody else in this room, we would gather together and talk about something, maybe share information, we call that clumped dispersion *(writes on the white board)*... so it means the individuals in a population are clumped. If we did not care about our position relative to each other's position, which would be a random dispersion *(writes on the board)*. But, we cared about our position relative to one another and perhaps wary of each other, then it would be uniform dispersion. So, clumped dispersion, we get individuals here (*drawing on the board – dots to represent organisms in groups)* living close to each other. With random dispersion, you have two here, you have one here and you have three there, one here and one there *(drawing dots...)*. But with uniform dispersion, you have one here and one there...it is uniform but it does not mean that the distance between these individuals, individual 1 and 2 (*naming the dots as individuals*) is the same. It is just a generalised explanation. So, it does not actually mean that there is that uniform, uniform; uniform... so, as I said (displays a slide with text). How individuals are spaced within 'range' (reading from the slide).

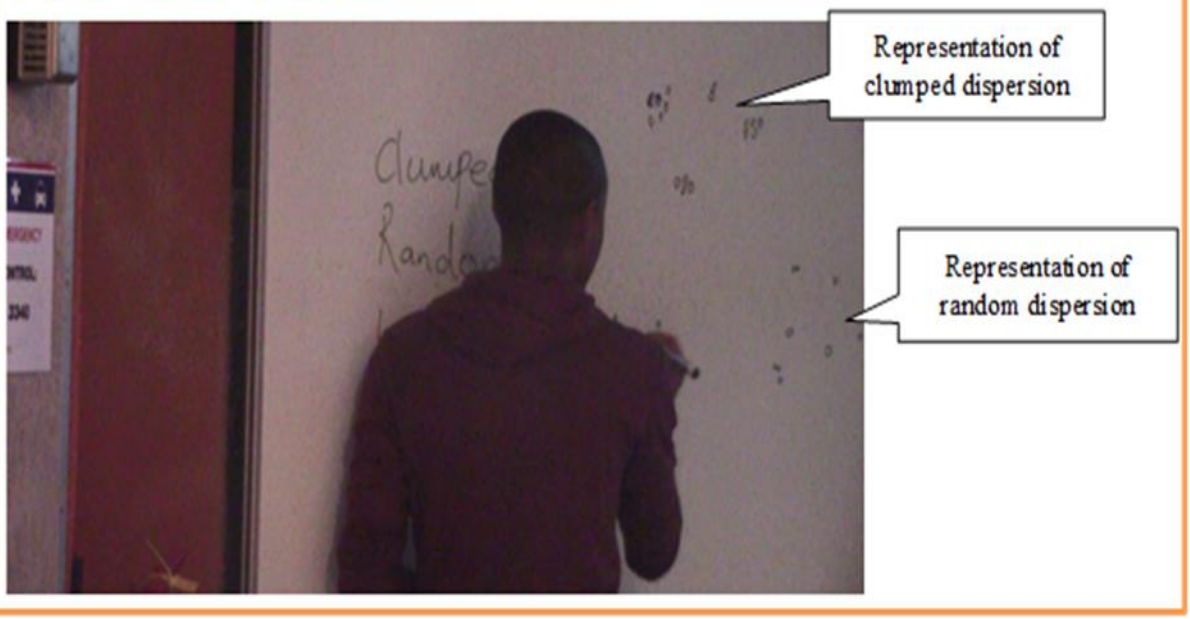



**Figure 7.1: Illustrating the three kinds of dispersion using an analogy**

**My reflection and lessons learnt:** The students' experiences of how I used the analogy is an indication and confirmation that analogies are powerful tools that can be used in biology lectures to help students grasp the science concepts (Mastrilli, 1997). I used the analogy with immediate reference to the science content, and this might be the reason why the students expressed their appreciation. I went on to speak about the interaction of people in a room and immediately described what kind of dispersion that would represent. I further wrote the biology terminology (the terms that explain the three types of dispersion) on the board as I drew the representations. Making immediate reference to the science content when using the analogy helped the students to internalise the correct information of the concept of dispersion. I realised that this is not only about the choice of the analogy but also about how I used the analogy to make sure that it portrays the science content that it should. The students confirmed that I have

been able to think of a single concept and have been able to select pedagogical approaches that I could use to teach that concept. In PCK, analogies are included as part of representations and are strong pedagogical tools that can enhance student learning, especially in relation to abstract concepts. Although the concept of dispersion is not abstract, as it can be observed in the environment, the analogy gave students an alternative way of thinking about dispersion. Representations are part of how PCK manifests in the classroom (Rollnick et al., 2008).

Although the students appreciated how I used the analogy, they still commented on how the use of examples to explain concepts was limited in most of my lectures:

**Fatima:** *Sometimes he would give one example, but it was not enough, especially with symbiosis. Maybe he could have referred us to a source for us to get a better picture*

**Teba:** *He gave us examples we see every day. I am from rural areas so I could imagine those and think of other examples*

**Debby:** *He taught well and understood his content, but I did not see a lot of examples used, so some of the things are still hanging, but we get the whole idea*

Leslie indicated that he learns better when a lot of examples are used to explain the natural phenomena. I taught the concept of symbiosis in the fourth lecture. For each symbiotic interaction, I showed one or two examples. However, the examples were still not enough for the students. Fatima provided a suggestion that a reference to the source of an example would have made things better. Although the examples were not enough, Teba thought that the examples I used were relevant to him as he witnessed some of these interactions.

**My reflection and lessons learnt:** The lessons that I draw here are linked to the theme which pertains to students critiquing my teaching approaches – that although the content was relevant to what they see in their everyday lives, the relevance was not explicitly portrayed to them. Two key points are emerging here about the use of examples when teaching biology. The first is the use of "enough" examples for the students to grasp the science concepts and the second is how the examples are relatable to students. With the first key point, it seems that the examples I used were not enough for the students to have a clearer picture of the interactions that happen in the environment. For me, the word "enough" seems to allude to the second key point of the relevance of the examples to the students. That is, are the examples used enough for most students to relate to them? Although I can use a lot of examples, the examples need to be related to the students. It is not every student who comes from rural areas like Teba who said the examples I used were what he witnessed. Therefore, Fatima's suggestion that I should

refer them to sources with varied examples would be an effective approach to cater for most students in terms of using diversified examples to explain interactions in the environment. I learned that the examples should be part of the teaching approaches that allow the students to explicitly see the relevance of the content chosen in their everyday lives.

### 7.3.5 Making links between lectures and tutorial and practical activities

I have indicated in the previous chapter how I planned to open and close my lectures to ensure continuity and coherence in my teaching. One of my strategies to open up my lectures was to use concept maps that summarised the content of the previous lectures. For closures, I included a slide that indicated key points covered in the lecture, what the next lecture was about and what the practical and tutorial activities were about. Although none of my students commented on my use of concept maps at the beginning of the lecture to recap on the previous lecture, they still commented on how the closures could have been strengthened and could introduce the opening of a lecture that comes after a practical session.

**Leslie:** *How you consolidate and make links in terms of the activities did not come out clearly, it was once where we had a discussion of the prac and challenges*
**Fatima** *He must do that often, talk about the prac that we did. I found it to be useful to reflect on what I wrote in the practical report*
**Pearl:** *He should show us the link, how they are connected or to what we are doing like the practical and lecture*
**Drake** *Sometimes in the lecture he would refer to the practical but I did not get it, how the content we gain in the lecture is used in the practical*

The three students raised concerns about how consolidation was done in the lectures especially making links between lectures and practical activities. Leslie appreciates the discussion that took place in the lecture that came after the first practical activity. The following excerpt is from lecture 2 and shows the discussion that took place where the links were made.

**1 (L)** *So, today's lecture, we are looking at the models of population growth. What they use to explain population growth. Okay, before I go into today's lecture, I wanted to explain what happened in the practical. There were some problems in terms of the formula and the apparatus provided. The problem was not with formula. The problem was with the material provided by the technician. So, if you have beans, beans take a large surface area*. (Explanation continued).
**2 (S1)** *S1: With Part 2, I experienced some challenges, for the steps that we have here, I felt that some steps were missing. I felt like there are some steps that are missing. I don't know if you wanted us to do the research or you assumed we have done that before.*
**3 (L)** *L: No, it was…okay, continue.*

**4 (S1)** *S1: For instance, with part B, where we had to do the mark-recapture methods, the steps did not indicate that you have to record the number that you had marked initially. And also, this table here has three columns where it is just the trial number, the number of captures and marked. It does not have a column for the number that you have collected. In the formula we used in the first lecture, it was a bit challenging*

**5 (L)** *You don't need that because the trial is 'marking, capturing and recapturing'.*

**6 (S1)** *So, when I did the calculations, I found them to be a bit challenging because I felt that at some point, you needed to have the number that captured and marked initially. (Explanation continued).*

**7 (L)** *So, 'M' would be constant; the bigger M…*

**8 (S1)** *So, on the steps, you did not say anything on the steps. So we needed to figure that out ourselves?*

**9 (L)** *It is not self-explanatory. It is something that you should have done before…*

**10 (S1)** *Yes, that is what I am saying…it was intentional?*

**11 (L)** *Okay, there was a hand over there?*

**12 (S)** *What I wanted to say is that this was part of the pre-lab where we needed to investigate on the different techniques used to estimate the population size. I am not sure if it was covered on Monday in the lecture,*

**13 (L)** *Okay, that is true. Okay, so today's lecture we are looking at…now I am starting formally with today's lecture.*

S=Student, L=lecturer.

The excerpt above shows the discussion we had with the students in the lecture after the first practical session. It can be seen that the students also seemed to have questions about what they did as they also commented during the interviews. The excerpt shows that for Student 1 and Student 2, it was some sort of a reflective exercise to reflect on the practical activity and make links to what they have been doing in the lecture.

**My reflection and lessons learnt:** When planning, I did not plan to start a lecture by talking about the practical that the students have done. However, I did that (as shown in the excerpt above) because of the challenges (change of practical material) we encountered in the first practical activity. I had to make this decision and shift my planning because of the circumstances at that time in point by thinking rationally. A lesson here is that the unplanned is put into practice when necessary, using the knowledge gathered and known by making justified pedagogical decisions.

The students have made me aware that in teaching biology, this is a good practice as it consolidates their understanding and helps them to "reflect" on what they did in the laboratories as Fatima pointed. Their participation in the lecture, as illustrated in the excerpt, shows that

revisiting what they had done in the practical session was necessary – not only to give them a brief overview but also to involve them. Some previous studies such as Scott, Mortimer, and Ametler (2011) indicate conceptual understanding is more than mentioning what has been covered and what will be covered. It involves synthesising the content into a whole and making clear links in teaching. There needs to be a continuous reference to the practical that is lined up as the lecture continues and a more consolidated reference at the end of the lecture. This should be a two-way activity in the sense that the introduction of the lecture after the practical investigation should also deal with questions and comments from the practical and how the theoretical content informs or is informed by the practical. I regard this as a missed opportunity in terms of strengthening the practice of making these links and being consistent for meaning-making. For example, the second practical was not consolidated in the subsequent lecture resulting in missing an opportunity for meaning-making. David attests to this by saying: "After that simulation, I was like why is this happening…it was really nice. If we came together to class after the practical as we did in the first practical, it could have been nicer to explore the questions".

### 7.3.6 Alignment of the content taught and how it was taught and summative assessment

In the previous theme, I presented lessons learnt about linking what is done in the lectures and the practical sessions. This theme is still about making links but focuses on the alignment of the lectures and the summative assessments given to the students. The students commented on the alignment of what happens in the lectures and the questions they had to answer in the test.

> **Ponelo:** *We're used to the standard that argh it's just content; you just read through with what you're, and then comes shocker you know? The questions are on another level, so, but the presentation of the content he gave us the impression that this is how he gonna ask questions. You know the questions that he asked in the lecture, they were quite straight forward, now he gives us another impression; when you got to the test Uh-hmm.*
>
> **Leslie:** *The test showed us, Yoh!! it showed us that what is in the lecture; first we underestimated it. I think because of the lecture slides and tutorials. We had tutorial questions, and I don't think there was one question from the tutorial. There was nothing.*

Ponelo indicates that the presentation of content in the lectures set the wrong impressions about how the test would look. For Leslie, the questions in the tutorials and lectures were simplified

to emphasise the misalignment of what I did in the lectures and the quality of questions I set in the test.

**My reflection and lessons learnt:** When I was reading the students' utterances, I noticed that the problem is not on the assessment (test questions) that I gave to students per se. The issue was on the *alignment of the content to the assessment*. According to what the students say, the content of population ecology was okay in the sense that it was pitched at their level both in terms of the choice of concepts, and how the concepts were taught. That is, the concepts taught were appropriate for their year of study as argued in the first theme. What seemed to bother the student is the "presentation versus expectations". What students meant by presentation in this context goes beyond using specific approaches and strategies I used to teach the topic. I realised that there is a breakdown in the chain of content choice/planning, instruction, and assessment (see figure 7.2 below). I asked myself if I should be creating expectations with the students and what this means in terms of assessment.

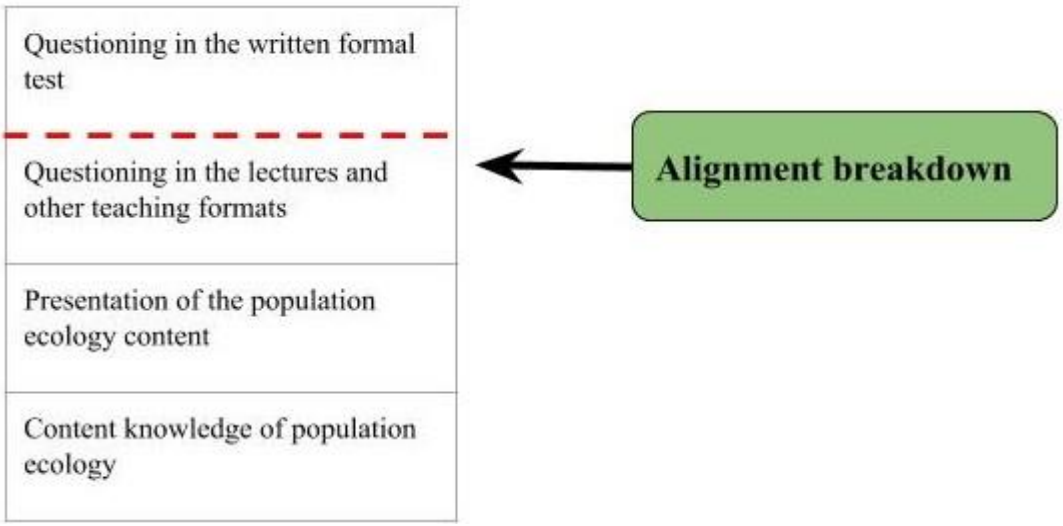



**Figure 7.2: The breakdown of the chain of instruction from planning to assessment**

Reflecting on my teaching and the test questions, I realised that my teaching and assessment lacked alignment because I was unable to clearly define what Biggs and Tang (2011) call Intended Learning Outcomes (ILO). These are the statements that outline what students should be able to do at the end of the teaching course. The ILOs must be defined before the commencement of teaching. So, whatever that I do in the lecture sends messages to the students about the summative assessment.

### 7.3.7 The discussions in the tutorial sessions consolidate their understanding of the content covered in the lecture

As discussed in the previous chapter, I planned questions for the students to discuss in the tutorial sessions. The questions were planned such that the students are compelled to do some reading before the sessions. As such, the students commented on the usefulness of these tutorial sessions.

**David:** *When we were in tutorials and people had to talk to each other. As we were talking, people came with new knowledge. It was interesting.*
**Debby** *A lot of what we did in the lectures made more sense in the tutorial. Things were becoming clearer*
**Drake** *I enjoyed the first tutorial, in my group, we came with our answers and discussed, and I learnt from my group members*

The points raised by David and Debby say a lot about the significance of tutorial sessions on their learning of biology content. His involvement in the tutorial sessions enhanced David's knowledge of population ecology. His knowledge was specifically enhanced by the interactions that he had with other students in the tutorial sessions, which gives additional credence to the importance of student-student interaction in learning spaces. In addition, Drake illustrates how discussing their prepared responses to the questions helped him learn from his group members while for Debby, *"*Things were becoming clearer*".*

**My reflection and lessons learnt:** My practice of giving the tutorial questions before the actual session seems to have worked for the benefit of the students. The utterances confirm that they were able to interact and consolidate their understanding because they had prepared for it. A lesson from this is that when teaching biology, tutorials are important. Depending on the institutional structures and regulations, students need to be given questions to answer before the tutorial for the discussions to be worthwhile. The questions must be phrased in a way that students can do a lot of thinking. This means including middle and higher-order questions and those that are open-ended to trigger meaningful discussions.

### 7.3.8 Authentic practical activities help students to imagine their future contexts

Biology involves practical investigations and experiments as part of student learning. In my planning, I had two practical activities as discussed in the previous chapter (also see Appendix N). Although tutors facilitate the practical investigations in each laboratory, my role as a lecturer was to continuously move from one laboratory to the other to clarify things if there

was a need. Students commented on their experiences around practical investigations as follows:

> **Ponelo:** *In the form of practical work I think I gained a few things as well like that myself I would apply in the classroom*
> **Fatima:** *The first practical was, I really enjoyed it, I would use it in the classroom in any school. I can buy the beans and get my students to do the same thing*

Fatima is more explicit in terms of the impact that the first practical had on her as a future teacher such that she will do the same practical with her learners. The fact that she says she will be able to use the same practical in her classroom indicates that she was able to think of her future teaching context whilst doing the practical investigation.

**My reflection and lessons learnt:** Practical activities that are authentic are important to help students imagine their future contexts as these activities model practice for them. The students' feedback confirms the relevance of practical activities. That is, the practical activities they did in population ecology were best suited for them as teachers. The first practical where students had to use the beans to model population growth can be used (as the students say) in schools that lack resources like computers to simulate population growth. Working within the assumption that these pre-service teachers come into the classroom with multiple layers of envisaged contexts (as a sub-set of the identity of students as teachers) that they would like to teach is perhaps due to their previous schooling or just personal desires. It is worthwhile for every biology teacher educator to consider these contexts when teaching through designing relevant practical activities. As a biology teacher educator, I need to develop these pre-service teachers to be able to pedagogically respond to context differences. The students' feedback indicates that they have gained the knowledge of pedagogy and were able to predict their future context, as they got involved in the practical and tutorial sessions. It is therefore important for me as a teacher educator to not just perceive the practical activities I plan as activities to disseminate content knowledge but also as activities to show students how practical activities can be planned.

### 7.3.9 Students learn about teaching from pedagogical practices

Modelling practice involves explicitly showing and telling students the effective practices of teaching biology. However, the students also paid attention to how I responded to situations in my teaching. The students said the following about how I modelled practice for them.

**Ponelo:** *Like how to conduct the experiments even when there is a shortage of resources coz that happened in our practical, was it our first? Yeah, I think it was our first practical like there was a shortage of resources and he had to come up with a plan on the spot coz he was not told that the apparatus would not be enough. So, that's also a skill that I learned that you have to think on the spot if you are a life science teacher you can't just decide to cancel the prac because the resources are not enough*

**Teba:** *I learnt a skill of breaking down content into pieces. Last year we did big ideas, like his strategy of representing topics was something I would do because I could see main concepts*

**Fatima** *He should have told us how this is good for learners and how we can teach this to learners, he did not do that thoroughly*

Ponelo was fascinated by how I facilitated the first practical investigation despite the shortfalls that we encountered with regard to the practical resources. More specifically, he learnt something about being a science teacher from the way I facilitated the session. This is part of showing students good pedagogical practices. Although Fatima confirmed that I did not explicitly model practice, as she said, *"He should have told us",* Teba paid attention to some of the things I planned like packaging my content and representing the topics as big ideas. See Appendix K for how I represented the topics as big ideas that I also showed in slides.

**My reflection and insights learnt:** It is clear that I did not explicitly model practice for the students by "telling them about effective approaches for teaching biology". I understand that even though I was unable to explicitly model practice in the lectures during the actual teaching, some of what I did as I was facilitating the practical sessions had an impact on how students would conduct themselves as teachers. This is an insight for me as a biology teacher educator because it made me realise that I send messages about teaching with every move that I take. For the students to learn the practices of teaching, they do not have to be explicitly told. Although that is desired, a significant difference in how they perceive teaching biology can be made, even when I implicitly model practice.

### 7.3.10 The use of a learning management system in teaching

The use of a learning management system (LMS) involves the students learning outside the classroom (outside contact sessions) and using online facilities to learn. Although Wits university has an LMS called SAKAI, when I was planning, I did not thoroughly think of how I wanted to use the system to enhance students' learning except posting announcements and uploading the PowerPoint slides. However, the students still commented on this aspect. David and Leslie commented as follows about how I used the LMS.

**David:** *As much as we come to lectures, it does not mean we learn 90% of the knowledge from that specific lecture…engage us online, put slides before class.*

**Leslie:** *We learnt in the lectures, and that was it. I would have loved to be engaged SAKAI like they do in course X, where we can ask questions in that thing, the discussion forum. Posting the slides after the lecture was not enough for me*

The students raised issues around the lecturer's effective use of learning management system platforms to enhance student learning. When I read what students said about how I used SAKAI as a platform to enhance learning, I asked myself a question: To what extent was I prepared for engaging students in the discussion forum? I thought uploading the slides on SAKAI was good enough, but David felt that the slides should be posted even before the lecture for them to prepare.

**My reflection and lessons learnt:** While I believed that I did use it effectively since I posted the slides and other resources on SAKAI after every lecture, I shared my view with Nimrod and our discussion yielded the lessons that I learnt about effectively using learning management systems to enhance teaching and learning of biology.

**Nimrod:** *Why do you feel like you did enough with utilising SAKAI?*

**My response:** *The main point of SAKAI is for the students to get notes and all the resources and get announcements, isn't it?*

**Nimrod:** *Hahaha…(laughs) you can also do tests there and like interact with them, see where they lack, we used to do that in course X, and it was nice*

**My response:** *I feel like that is not necessary for me, I engaging them in the classroom mos, even in the tutorials*

**Nimrod:** *But, what if I am shy in the tutorials? Maybe I can ask a question there [SAKAI], and other will not know that it is me.*

At the beginning of my study, I used SAKAI as a site where I post the lecture notes and post announcements. I did not understand the reasons why I need to go beyond what I was doing. The conversation with Nimrod helped me to think of how I can use SAKAI to enhance students' learning of biology content. Below, I present, three ways in which the learning management system can be utilised without compromising contact sessions that are still necessary for students' learning.

- Engaging the students who are shy to ask questions during contact sessions – It is important to use the discussion forums on the LMS to cater for the students who may have questions but afraid to ask during contact sessions.

- Uploading the notes before lectures – the practice of giving students the slides before lectures helps students to prepare for the lectures in advance. The aim would be to give them a glimpse of what the lecture will be about that may, in turn, help them come to the class with questions.
- Giving students short activities to do before class – another way of utilising the LMS is to give students a short multiple-choice activity before the actual lecture. This would serve a different purpose from engaging them because the idea here is to just get their prior knowledge on the concept to be taught. At the end, the students test their understanding and get a glimpse of the lecture focus. The lecturer gets a chance to analyse their responses and tailor the teaching to address specific misconceptions that may have arisen.

The three practices described above are aspects of what makes a flipped classroom. Concerning the third practice, such a practice can be used for diagnosis since I would get to understand the level at which students are for a selected concept. As a result, the teacher educator would be gaining the knowledge of students that is necessary for teaching. According to Bergmann and Sams (2012), a flipped classroom allows students to gain exposure to the content before the actual teaching in the classroom. My understanding is now that the learning management systems can be good tools to flip the classroom and enhance the teaching and learning of the pre-service teachers.

### 7.3.11 The role of lecturer's conduct on pre-service teachers' learning of content

This aspect of practice does not link directly to the teaching of biology, but it is important in teaching and learning of pre-service teachers. Students seem to have certain conceptions of their lecturer based on how the lecturer conducts himself, leading to this kind of interaction influencing the teaching and learning process. The students had the following to say:

**Drake:** *The personality of Climant, the lecturer being himself we go through emotions which go up and down. But, I don't recall a time where I could say the lecturer was moody or something like that. That made my learning a bit simpler*

**Hilda:** *Climant built that trust; you can actually go to him and ask him anything. I think that is why I was able to talk in his lectures and ask questions; even when we came across him in the concourse, he would greet you with a smile, and you can stop him and talk to him about anything*

Students' observations show that they were paying attention to how I conducted myself and how I interacted with them beyond biology content knowledge related purposes. Drake, for example, points out that the way I carried myself or the personality that I portrayed in the lectures had an impact on how he learnt the content. He indicated that it made his learning simpler. Talking to students with a cheerful face that is full of joy ignites their interest in learning. Hilda is clearer by saying that I have established the trust to the extent that she can come and ask me anything, including the content questions in the classroom.

**My reflection and lessons learnt:** Because I showed interest and care through my interactions with them (students), they felt free to ask me questions during lectures as and when they do not understand. I managed to gain the students' trust first by holding short discussions with them outside the formal lecture slots. Talking to students with a positive face that is full of joy ignites their interest in learning. Students specifically referred to me as a "social person", and this is important for the construction of my identity as a teacher educator. The inability of a teacher educator to show care and interest in students demotivates the students and contributes to their choice of doing the course for passing only. What I do as a teacher educator sends messages about the kind of person I am, about the content that I am teaching, and about how I would expect the students to view and interact with me. According to Hagenauer and Volet (2014), the relationship and interaction between the lecturer and students influence how students learn. As part of encouraging the students to learn, I should exercise care, humility and establish trust. Furthermore, Hagenauer and Volet (2014) investigated the teacher-learner relationship and suggest that there are two dimensions of the teacher-student relationship in higher education. The first is affective, which has to do with building positive relationships grounded by a strong bond between the lecturer and students for forming a secured relationship and positive experiences. The second is supportive and it has to do with being available for consultations and giving students the necessary aids to learn. What this means to me as a novice teacher educator is that I need to establish these two dimensions at the start of teaching to gain the students' attention and continue with this behaviour to sustain the students' motivation for learning. Table 7.3 below shows how I can establish these two domains drawing the students' feedback and my experiences of teaching the students.

**Table 7-3**

**Ways of establishing affective and support dimensions for a positive lecturer-student relationship**

| | **Affective dimension** | **Support dimension** |
|---|---|---|
| During contact periods (lecture, tutorial, and practical sessions) | Listening to students' grievances.<br><br>Showing a cheerful face to develop comfort in students. | Encouraging students to ask questions and answering the questions promptly.<br><br>Using different teaching approaches to cater to different students.<br><br>Interacting with students during the laboratory sessions. |
| During non-contact times | Greeting my students in the corridors.<br><br>Treating individual students' issues in confidentiality | Responding to student emails promptly.<br><br>Posting relevant learning materials on the LMS.<br><br>Assisting students with questions even if they do not come during consultation times. |

Table 7.3 above shows how I could strengthen the interaction between myself and the students that I am teaching to have a strong lecturer-student relationship for learning. The strategies I identified are not exhaustive, and some may apply to specific students. Some of the strategies are also similar to those identified in the literature (Hagenauer & Volet, 2014; Jacklin & Le Riche, 2009). The extent and nature of this care are defined based on the instructional goals and whether this care enhances students' learning and possibly the development of students' interpersonal skills.

## 7.4 THE SIGNIFICANCE OF EVALUATING ONE'S TEACHING USING STUDENT FEEDBACK

In the previous section, I presented my reflections and lessons learnt from student feedback on my teaching. The idea of using student feedback was to assess my teaching and look at areas of learning about my teaching. This was done when students commented on my teaching practices which were informed by what I learnt as presented in the previous chapters. Therefore, the students' feedback also served to confirm if the learning has occurred.

Analysis of the student interviews as a lens to assess my learning confirmed that the learning occurred. This, in turn, confirms that the approaches I used to learn about teaching biology to pre-service teachers work for a novice teacher educator. Most of the aspects of practices that the students commented on are the practices that I learnt through exploration by discussions,

observations, and engaging in my own planning. For example, I engaged in an exploration of determining the depth of the content, and students have commented that the nature and level of content they learnt was appropriate and relevant to them as pre-service teachers and as members of the society. This confirms that the idea of learning about planning by exploration that is focused on one aspect was successful. The students' reference to such practices is an indication that the learning occurred and that their feedback or the idea of assessing my teaching is significant for a novice teacher educator's learning to teach

The students also commented on how the lectures were interactive because of the design of the PowerPoint slides and the use of worksheets. Looking back at how I learnt, the learning commenced through the exploration of my experiences as an undergraduate, proceeded through observations of experienced teacher educators where what I learnt was continuously modified and ultimately put what I have learnt into practice. These modifications happened because I engaged in continuous reflection that required decision making as I used the knowledge gained. Some of what I had done in the lectures that students referred to were not planned while some were planned using the knowledge I gained as a basis. In the planning and teaching, I still exercised my judgement. For example, taking a decision that I need to refer back to the practical helped me to realise that decisions taken rationally by the teacher educator benefit the students. This explains the idea of practical wisdom (Cooke & Carr, 2014).

Although the findings in this chapter confirmed the significance of student feedback in assessing one's teaching to draw conclusions about one's learning as a novice, the findings also demonstrate that one can still learn about practices of teaching pre-service teachers. These practices may or may not necessarily be those learnt previously and put in practice. For example, in my way of learning, I did not focus on strategies of ensuring alignment between what happens (teaching approaches and how I pitch the content to students) in the lecture and the quality of questions asked in the tests, but students commented on this aspect. This propelled me to reflect on it and gain insights. The findings suggest that student feedback can also be used to learn about practices of teaching that a lecturer never thought about leading to improvement in teaching. This confirms what is already in the literature (Floden, 2017; Wong & Moni, 2014). The students also critiqued the teaching approaches I used in relation to the content chosen, leading me to further reflect on these critiques and learn more about teaching biology to pre-service teachers. As Floden (2017) states; student feedback is more beneficial when the lecturer takes the critiques and views them as learning opportunities. Despite learning

about teaching approaches, I still reframed the critiques from the students to develop my professional skills.

Gathering and using student feedback to learn about teaching has a professional value for the teacher educator. Hativa (1997) found that faculty members learnt a lot about practice from student feedback, as this allowed them to engage in self-introspection. Reflecting on the student feedback allowed me to look at myself, my teaching, and learning from the perspective of students. After all, everything that we do needs to be in the best interest of their learning. Although according to Fletcher, Chróinín and O'Sullivan (2016), interaction with pre-service teachers through getting their feedback and reflections helps self-study researchers to validate their interpretations of practice, it also helps in improving practice, and this can be immediate. In other words, it helps us as teacher educators to challenge our teaching in context and question our pedagogical practices to improve students' learning.

## 7.5 CONCLUDING REMARKS

This chapter was about looking back at my learning through the lens of student feedback on my teaching of the topic of population ecology. Its main contribution in the thesis is how student feedback is a tool that can be used to look back at one's learning. I planned my teaching and taught using the insights gained as I explored my learning. The main point from this chapter is that student feedback can be used as a lens to assess the novice teacher educator's learning of the practices for teaching biology to pre-service teachers. I started this chapter by describing the data analysis approach I used to analyse the interview transcripts then presented my reflections and lessons learnt from the students' feedback. The student feedback did not only help me evaluate my teaching but also the learning approaches that I have used in the study. That is, learning about teaching biology through exploration and focusing on specific aspects of practice. In the next chapter (Chapter 8), I draw conclusions from this PhD study and show how I have addressed my research questions.

# CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

## 8.1 INTRODUCTION

In this PhD study, I used a self-study methodology to explore how as a novice teacher educator, learn to teach biology to pre-service teachers and the practices and pedagogies of teaching biology to pre-service teachers. In this final chapter, I present the concluding insights and address my research questions using the findings presented in Chapters 4 to 7. The concluding insights are about how learning occurred and the key practices of teaching biology to pre-service teachers thereof. I also provide my methodological reflections and recommendations for future research.

This study was guided by the main research question: "**How do I learn to teach biology to pre-service teachers?"** This research question had four sub-questions:

1. What do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?
2. How do I learn about teaching biology to pre-service teachers from experienced biology teacher educators?
3. How does planning and teaching a biology topic help me learn to teach biology to pre-service teachers?
4. What knowledge about my teaching do I gain from students' feedback?

## 8.2 EXPLORING WITHOUT BORDERS: THE UNCONFINED AND ILLUMINATING MEANS OF LEARNING

In the chapters presenting the findings, I have demonstrated how I learnt to teach biology to pre-service teachers in different ways. The first means of learning to teach biology to pre-service teachers was through an exploratory approach, "exploration without borders". Exploration without borders means the novice teacher educator explores the practices and pedagogies of teaching pre-service teachers without confining oneself to specific practices and aspects of teaching. Below, I present the approaches that I used in this study as part of my

exploration without borders and then draw from the findings; what should characterise these approaches.

### 8.2.1 Interrogating the experiences accumulated over the years as a pre-service teacher: A foundation for learning to teach

As one passes through teacher training as a pre-service teacher, one accumulates a lot of baggage through the apprenticeship of observation (Oleson & Hora, 2013). This baggage includes assumptions about how the teaching of pre-service teachers ought to be done and some naive ways of looking at the teaching practices of biology teacher educators. Therefore, as part of learning to teach, I had to examine and interrogate these assumptions critically. As I was reflecting on my experiences as a student, I began to "see" in a different way, some pedagogical aspects that I had negatively experienced. Reflecting on my experiences as a pre-service teacher as part of learning to teach made a significant impact on how I engaged with the experienced teacher educators, students, and my practice during my learning to teach journey. Samaras et al. (2004) argue that we can use our experiences as students as tools to understand our current practice and contribute to the conceptualisation of what it means (or rather should mean) to teach.

This study has demonstrated that in learning as a novice teacher educator, referring back to the experiences that one has built up over the years should be the first and foremost key practice of a novice teacher educator as it forms a foundation for the development of one's practices of teaching pre-service teachers and one's professional identity. Reflecting on such experiences helps one to learn to "become" and gradually move to the core of the domain in the space of working with experienced teacher educators as they explore the key pedagogies of teaching pre-service teachers. As Oleson and Hora (2013) argued, it is important to reflect on these experiences not only as a way of avoiding to teach the way we were taught but to also develop our own identities in teaching. From the findings in this study, I, therefore, suggest that when novice teacher educators enter the teacher education space, the first thing to do should be that of reflecting deeply on their experiences as pre-service teachers. The reflections help to facilitate new learning in the teacher education space as the new perspectives gained are used to make sense of new experiences.

### 8.2.2 Observing experienced teacher educators as they teach and discuss their teaching practice: Approaches that help one to learn about teaching pre-service teachers

After interrogating my experiences as a pre-service teacher, I had a different and better understanding of the practices and pedagogies of teaching biology to pre-service teachers. This formed an effective foundation for how I reflected on experienced teacher educators' observations. I learnt about teaching biology to pre-service teachers from observing experienced teacher educators' practices and having informal discussions with them. Although I was not focusing on specific aspects of teaching (exploring without borders), I still ended-up learning specific practices that I was noticing during my observations e.g. the practice of randomly picking students to answer questions in lectures and its effect on students. One factor that made learning possible is that I was not just an observer. The experienced teacher educators made me part of their community of practice (Lave and Wenger, 1991; Patton & Parker, 2017) in the sense that they engaged with me and gave me a sense of belonging. This study, therefore, showed that for learning from observations of experienced teacher educators to occur, the novice teacher educator has to work as an apprentice within the community of experienced teacher educators. Furthermore, the community of experienced teacher educators with the novice teacher educator needs to be interactive in the sense that the novice teacher educators have to construct their conceptualisations of practice with the help of experienced teacher educators as the knowledgeable others or experts (Patton & Parker, 2017). This finding is supported by what Abell et al. (2009) argued – that experienced teacher educators need to, through interactions that involve talking about pedagogies of teacher education, provide guidance on what it means to teach pre-service teachers.

Observing the experienced teacher educators was accompanied by informal discussions where I learnt why the teacher educators used certain teaching approaches. The experienced teacher educators revealed their pedagogical reasoning (Mansfield, 2019). Their pedagogical reasoning helped me to understand the practices in context and why I was not observing the same practices in all the other experienced biology teacher educators. Furthermore, the experienced teacher educators' pedagogical reasoning moved me from the naïve ways of thinking about teaching pre-service teachers as I continued to critically reflect on my experiences. There are certain teaching approaches that the educators used when I was a student that I considered irrelevant and not working, a line of thinking that changed because of their reasoning coupled

with the reflections on my experiences as discussed above. This then led to the development of my professional knowledge for teaching biology pre-service teachers.

As we were discussing, the experienced teacher educators also asked for my opinion on some of the practices they used as a way of orientating my thinking in biology teacher education practices. From these discussions, I was able to abstractly conceptualise how the teaching of biology to pre-service teachers could be. Explicit pedagogical reasoning was, therefore, a two-way process for the novice teacher educator to have a deeper understanding of what guides the experienced teacher educators. The practices that I have learnt indicated that observing experienced teacher educators and asking them why they use certain pedagogical practices is an effective way of helping the novice teacher educator to learn about the knowledge and practices of teaching pre-service teachers.

### 8.2.3 "Bitesize' teaching practice accompanied by feedback: A gentle and effective way of learning how to teach

My first practice as a teacher educator comprised of a short period of planning and teaching for a week. Teaching for a week enabled me to apply practically what I had learnt as I engaged in teaching the pre-service teachers for the first time using the knowledge of teaching biology I had gained at that particular point in time. Being provided with an opportunity to practice teaching for just one week coupled with written feedback from the students was a gentle and effective way of allowing me to learn to teach. I was "free" to try anything that I thought could work. I got an opportunity to look at the teaching and learning of biology as a teacher educator and not as a student before being given the responsibility of teaching a full topic or module. This teaching opportunity provided a space for "testing" the insights gained from my reflections on my experiences and the naïve conceptions I had about the teaching of pre-service teachers.

As I was teaching the pre-service teachers, I was implementing decisions without having an idea of how the results would turn out. One key aspect that made this learning approach effective was the idea of seeking students' feedback. Students' feedback coupled with continuous reflection revealed some of the teaching practices that needed further exploration. For example, from the student feedback, I came to understand how the use of biology terms when explaining biology phenomena, without having explained the meanings of the terms first,

can inhibit students' understanding of content. This feedback then prompted me to find ways of overcoming this challenge. The main insight, therefore, that this study is bringing forth is that providing a novice teacher educator with a short period of teaching, as a "trial run" works, as it enables the novice teacher educator to try out those personal theories, that is, theoretically-unfounded pedagogical practices. However, the approach works better when the students are part of the novice teacher educator's learning. I would not have gained the insights that I gained had I not requested feedback from the students as a supplement approach to learning to teach.

## 8.3 MOVING FROM THE GENERAL OBSERVATION OF TEACHING PRACTICES TO OBSERVATION AND DISCUSSION OF PARTICULAR PRACTICES: AN EFFECTIVE WAY OF FURTHERING LEARNING AND OF CONSOLIDATING LEARNING OF SPECIFIC TEACHING PRACTICES

In the findings chapters, I have demonstrated how I learnt to teach biology to pre-service teachers by focusing on specific practices of teaching. This was a continuation of exploring without borders and uses the insights gained as a basis. Below, I present two approaches of learning to teach pre-service teachers as part of focusing on specific aspects of practice.

### 8.3.1 Zooming into particular pedagogical practices when observing experienced teacher educators

After practising teaching for a short period, as indicated in the preceding section, I gained insights that needed further exploration. This further exploration is what I am referring to as *moving from the general to the particular.* This move from the general to the specific allowed for consolidation of learning of specific pedagogical practice. Focusing on specific aspects of teaching increased my awareness of how to do certain things as opposed to looking at the whole teaching practice of experienced teacher educators. I was able to gain more insights about how to promote interaction, effectively facilitate student questions and responses, deal with biology terminology and model teaching practices because of the focused observations approach. The focused observations helped me to "zoom in" on specific practices and to see subtle features of those practices that I would not have seen had I continued to engage in the general observations that I had done during the exploratory phase. This study has, therefore shown that focusing on specific practices is significant and should precede the approaches where there is

exploration without borders. However, reflection remains a critical activity for the novice teacher educator as an abstract conceptualisation of these practices is still necessary.

### 8.3.2 Zooming into particular practices of planning: An effective approach to understanding the principles of planning to teach a content course

The act of teaching cannot be separated from planning. As such, planning to teach pre-service was also my focus as I was learning to teach biology to pre-service teachers. This study has demonstrated that discussions that are focused on one dimension of teaching pre-service teachers, like planning, helps one to get a deeper understanding of that dimension. From formal discussions with the experienced teacher educators, I learnt key steps to follow when planning to teach a content course to pre-service teachers such as the need to consult the school curriculum first. I was able to learn and understand the planning principles because we had focused the discussions on one aspect of practice; that is planning to teach biology to pre-service teachers. Furthermore, I learnt that planning to teach a content course to pre-service teachers is a step-by-step process.

The study further showed that while focusing on one aspect of the practice, zooming deeper into that aspect is crucial as this reveals subtle practices that are often taken for granted. For example, in this instance, I zoomed in to find out from the teacher educators how one can determine the depth of content that pre-service teachers need to learn as a principle of planning and as a particular item of interest. The discussions on this item revealed how experienced teacher educators struggle to determine the content. This revelation led me to engage in some kind of exploration of how I could determine the depth of content for teaching the pre-service needed thereby ultimately arriving at a framework that I can use (See Chapter 6 Section 6.3). The difference between this exploration and the one discussed in the previous section is the specificity. This exploration was focused on one particular item of interest about planning (determination of content depth), thus, allowing for a deeper examination and discovery of new insights. The conclusion is therefore that although the novice teacher educator can focus on the particular, there might be a need to continue with the exploration of a specific aspect of practice to gain a better understanding of some practices. Hence, learning to teach biology to pre-service teachers may become a continuous exploration of specific practices.

## 8.4 MOVING TOWARDS "EXPERTISE": PLANNING AND TEACHING A FULL TOPIC

In this study, having gained a robust understanding of what it means to teach biology and the repertoire of the pedagogies for teaching biology to pre-service teachers, from 1) exploration through reflecting on my experiences as an undergraduate student, 2) to the general and informal discussions with the experienced teacher educators, 3) observations that focused on the particular, I now had formed a solid foundation of the knowledge of teaching biology to pre-service teachers. The above activities had enabled me as a novice teacher educator to enter the domain of teacher education and to be encultured into the community by the experienced teacher educators. Moving to the core of the domain was now necessary for showcasing the expertise, i.e. planning and teaching a full topic. I had to put my abstract conceptualisations in action. Therefore, I was given a three-week biology topic, population ecology, to plan and to teach with less involvement of the experienced teacher educators.

**Experiences of planning and teaching a full topic:** By planning and teaching a full topic, I got to understand the dynamic nature of teacher education and of teaching pre-service teachers. The knowledge that I had gained became invaluable *not as the knowledge I can apply but rather as the knowledge I can draw from to inform my practice*. This is an indication that despite learning by observing others, I still had to take a step back and ask myself the question "what does this mean for me" in an attempt to develop my identity as a biology teacher educator. I learnt that as one draws from the bag of the pedagogies learnt, one has to exercise caution as guided by what they are teaching and who they are teaching. This confirms what is in the literature, namely that learning from observing others is a good approach as the insights gained serve as a model and practices that the novice teacher can draw from (Bruce, Ross, Flynn & McPherson, 2009).

This study, therefore, showed that showcasing expertise helps the novice teacher educator to not only gain new insights but develop the skill of making professional judgements which is knowing what to use and when to use it rationally in consideration of socially and contextually embedded factors (Cooke & Carr, 2004). Professional judgement is the ultimate skill in developing the novice's knowledge base for teaching. This judgement involves a purposeful and systematic thinking process that evolves in terms of accuracy and insight with ongoing reflection and self-correction. The essence of the expertise of the novice teacher educator is

seen through his ability to make professional judgements and develop practical wisdom that is accompanied by continuous critical reflection (Kinsella & Pitman, 2012). As Dottin (2009) argued, it is not enough for a teacher to possess the repertoire of pedagogies that are necessary to teach. It is important to foreground sound professional judgment in varied contexts as a sign of learning. It is through showing sound professional judgement and evidence of practical wisdom that one develops their identity and understand their roles in certain contexts.

## 8.5 TAKING STOCK: FEEDBACK AS A MEANS TO ASSESS YOUR LEARNING AND GAIN FURTHER INSIGHTS

This study has demonstrated how seeking continuous feedback from students helps one to assess the quality of one's teaching and in the process to learn about teaching biology to pre-service teachers confirming what is in the literature (Ang et al., 2018; Blair & Valdez Noel, 2014). The feedback from the students confirmed the expertise that I had acquired by highlighting the practices and pedagogies of teaching biology that I had displayed in my three weeks of teaching. In addition to highlighting my teaching practices, the students also raised concerns about some of the aspects of teaching to which I did not pay attention. For example, they raised issues about the lack of alignment between the formative assessment that was happening in the lectures and the summative assessment. Assessment became one of the significant aspects of teaching pre-service teachers that did not feature anywhere in my journey of learning about teaching. This aspect from students' feedback has therefore revealed that learning to teach (in this case learning to teach biology to pre-service teachers) is not a once-off activity. It continues (or should continue) throughout the teacher educators' career. However, the learning should be coupled with continuous gathering of and reflection on students' feedback on one's teaching. This study has also demonstrated that gathering students' feedback is not only an effective way of assessing the quality of one's teaching but it also creates a space where new insights may arise for further learning. Learning from student feedback should, therefore, be one of the approaches that not only the novice teacher educators can use but also the experienced teacher educators for their professional growth.

## 8.6 THE PROPOSED MODEL OF LEARNING TO TEACH PRE-SERVICE TEACHERS

The conclusions presented in the previous sections outline specific approaches in which a novice biology teacher educator can learn to teach pre-service teachers. In other words, they are about how learning the practices and approaches to teaching biology to pre-service teachers can occur. As indicated in Chapter 1 that there are no studies that suggest how a novice teacher educator can learn to teach pre-service teachers. The proposed model is an attempt to contribute to this gap by suggesting a systematic way for one to learn to teach pre-service teachers. This is the new knowledge that this PhD is contributing to the body of knowledge. Although the focus of this study was specifically about teaching biology, the insights reported in this thesis, especially the approaches for learning, can be applied to any novice teacher educator seeking to learn how to teach pre-service teachers. Using these insights, I propose a model or framework for learning that novice teacher educators can adopt not only to acquire practices of teaching pre-service teachers but also to track their learning. This framework is summarized in Table 8.1 and draws from the conclusions presented in the previous sections of this chapter.

*Explanation of the model*

The model shows how the novice teacher educator can move from learning approaches that are based on general practices of teaching to specific practices. That is, exploring teaching pre-service teachers without focusing on specific practices and then moving to focus on particular practices. This approach increases the opportunities for learning as a novice teacher educator can explore without borders and engage in trial-and-error techniques as a means of learning. It is important to note the significance of the involvement of experienced teacher educators and their role. Their role is to not only to guide the novice teacher educator but also to make their own pedagogical reasoning explicit to enhance the novice teacher educator's reflection and interrogation of experiences. This explicit articulation of pedagogical reasoning from the experienced teacher educators' side strengthens the community of practice and building of the repertoire of practices for teaching pre-service teachers.

The exploration described above has the potential to allow the novice teacher educator to identify specific aspects of practice that need further exploration. The model shows how the novice teacher educator then has to focus on those particulars. The particulars are about

planning for teaching a topic or course for a prolonged period and specific teaching approaches that are seen as suitable and effective in teaching pre-service teachers. The essence of the movement from general to the particular is to “zoom in” into the observations and discussions with experienced teacher educators. Therefore, the discussions would no longer be about any dimension of teaching pre-service teachers but will be focused on planning practices in preparation for the novice teacher educator working alone.

The novice teacher educator is now fully encultured into the community and has a solid understanding of the knowledge and practices of teaching pre-service teachers. This then calls for the novice teacher educator to put what is learnt into real-time practice by planning and teaching a topic or course over a prolonged period to showcase expertise developed over time. The planning, teaching, and seeking student feedback is a means of judging the prior learning approaches that the novice teacher educator has undergone and finding out if there are new lessons that they can learn. The model assumes that support for the novice teacher educator is slowly withdrawn as learning continues and the novice teacher educator is allowed to explore further as they have laid a solid foundation of the practices of teaching pre-service teachers.

**Table 8-1**
**A proposed model for learning to teach pre-service teachers**

| | | Learning approaches (LA) | Key personnel involved | Important practices |
|---|---|---|---|---|
| **Assessment of what is learnt through student feedback** | **A. General–based learning approaches (Exploring without borders)** | **LA1** – The novice teacher educator reflects on his/her experiences as a student and as a school teacher | Novice teacher educator and critical friends | Reflection and interrogation of the accumulated experiences |
| | | **LA2** – The novice teacher educator observes experienced teacher educators | Novice teacher educator<br>Experienced teacher educators | Explicit pedagogical reasoning from both the novice teacher educator and experienced teacher educators |
| | | **LA3** – The novice teacher teaches a topic for short period | Novice teacher educator<br>Pre-service teachers taught<br>Experienced teacher educators and critical friends | Experienced teacher educators provide guidance through observing the novice teacher educator and questioning. Students give feedback. Novice teacher educator reflects on feedback from both the experienced teacher educators and the students with input from critical friends |
| | | **LA4** – The novice teacher educator requests feedback from the students taught (continuous – after every lecture) | Novice teacher educator<br>Pre-service teachers taught | Reflection of a novice teacher educator on the student's feedback – on a continuous basis (reflecting on student gathered after every lecture |
| | **B. Particular – based learning approaches** | **LA5 –** The novice teacher educator observes specific pedagogical approaches in experienced teacher educators' lectures | Novice teacher educator<br>Experienced teacher educators | The novice teacher educator reflects on the observed practices and the discussions about planning for teaching a topic |
| | | **LA6 –** Discussions with the novice teacher educators about planning | Novice teacher educator<br>Experienced teacher educators | Experienced teacher educators provide guidelines on how the novice teacher educator can plan for a topic or course |
| | **C. Taking a step forwards and displaying expertise** | **LA7**– Planning and teaching a topic for a prolonged period | Novice teacher educator<br>Pre-service teachers | Planning and teaching of the novice teacher educator and making professional judgements |
| | | **LA8 –** Seeking student feedback for evaluation of the quality of teaching and for further learning | Novice teacher educator<br>Pre-service teachers taught<br>Critical friends | Novice teacher educator reflects on the student feedback as guided by what was planned and taught |

## 8.7 MY REFLECTIONS AND INSIGHTS ON THE METHODOLOGICAL ASPECTS OF THIS STUDY

I used the self-study methodology to explore how I learn to teach biology to pre-service teachers as a novice teacher educator. I used a range of data collection methods as required in self-study. Below, I present some of the insights that emerged as I engaged in data collection and data analysis.

### 8.7.1 Conducting interviews

In self-study, the interviewees are usually asked to say something about the researcher and the researcher's practice – the individual who is undertaking the self-study. Since I was the one researched, the interviews were conducted by someone else. Firstly, from the interview transcripts analysis in this study, there was evidence that students truly revealed their experiences (as also seen in the teaching transcripts) because they were not interviewed by the one whose practice was researched. This confirms what is in Nyamupangedengu and Mandikonza's (2018) study that students tend to give rich and useful information about one's practice when asked by someone else. Secondly, the richness and depth of the data in the interview transcripts were due to the interviewer's probes. Probing was possible because the interviewer familiarised himself with my focus of the study. The interviewer was someone who had been in my lectures at least twice and had watched my teaching videos. This explains why he was able to probe and interrogate the students' responses. In this way, the students provided details about specific incidents that took place in the lectures. An insight from this in terms of using interviews as a data collection method in self-study or qualitative studies, in general, is that the interviewer has to be firmly embedded into the study and understand the demands and expectations of the interview questions.

### 8.7.2 Using a reflective journal

I used a reflective journal to capture my experiences, thoughts, and teaching ideas of my practice. The reflective journal also helped me to voice my feelings and emotions. In Chapter 3, Section 3.4, I have indicated that I would propose a "less messy" way of journaling when learning about my own practice. There are three methodological insights about using a reflective journal emanating from my self-study. The first is about separating the journal entries and reflections so that the analysis becomes less messy. The second is about indicating specific times of the journal

entry. The third insight is about the access of the reflective journal and how what I would term an audio-journal was convenient for me.

At the beginning of the study, I had only one notebook where I scripted my personal feelings, teaching notes and my responses to critical friends' comments on my teaching and thoughts. I found this to be disorganised when I looked at the data, despite the availability of dates. I later had three journals for entries that served different purposes. The first, which I referred to as a pedagogical reflective journal was the one with teaching ideas where I recorded a synopsis of my pedagogical thinking and initial reflections including my reflections on my lectures. In the second one, I recorded the critical friends' feedback and initial responses and reflections on their feedback and comments. The third one was primarily about my feelings, emotions and daily observations including random, informal discussions with people and students. I found the practice of separating journal entries to be useful in self-study.

In the beginning, although my journal entries were always dated, I did not include specific times. When I revisited the journal entries for further reflections and formulation of narrative texts and stories, it was a challenge for me to draw trends on how my thinking was changing and shifted especially when more than one entry was made in one day. Therefore, specifying the time served as reminders to make links between the entries and start to draw trends. The suggestion here is, therefore, that when engaging in self-study, one needs to specify the exact times in the journal entries to track one's reflections.

In many cases, I had thoughts and teaching ideas in areas where I did not have access to the reflective journal. I, however, had a recording device (cell phone) and used it to record my thoughts. In other words, I verbally articulated my thoughts and saved the recording. This was key for me because I later listened to the recordings and found them to be richer and more articulate than those put down in a book. Furthermore, I sometimes could not find words to express myself on paper but recording my voice became effective as I would freely talk and articulate my thinking. An insight from this is, therefore, that electronic devices like cell phones can be used as effective tools to serve as reflective journals since they are in our possession most of the time. A reflective journal does not have to be a hard copy where one needs to record their observations by writing. It can be recordings because thoughts, especially in self-study, can occur at any time. Audio

recordings of my thoughts helped me not to miss the important insights and reflections that came at a time where I had no access to my hard-copy reflective journals.

### 8.7.3 Insights about critical friendship in self-study

When I began with this PhD, I had to choose critical friends and work with them throughout this study. I ended up with a variety of critical friends from different contexts and ways of thinking. For example, having critical friends that are school biology teachers gave me a perspective of teaching and learning of biology in schools and this was key in my study because it informed how I plan and teach the pre-service teachers in preparing them for teaching. Having critical friends who were not necessarily biology teachers but engaged in self-study helped me in the sense that their comments also pointed to methodological issues. For example, they helped me to reflect and discover what reflection means. A lesson from this is therefore that self-study practitioners should have a variety of critical friends that allow a range of perspectives and broad understanding of pedagogical, social, and contextual factors that can influence one's teaching or the practice under investigation.

### 8.7.4 The nature of self-study

Firstly, when I started with this PhD study, I had an understanding of what educational research and the conventional ways of doing research. I was used to the notion that once data is collected, the analysis begins and writing of findings follows from the analysis of data. In self-study, data is also embedded within one's thoughts and reflections. This means analysis begins with the thought of practice and making sense of that thought. This had implications for how I report such that the report is a synthesis of insights that contribute to the field. The idea of breaking the conventional ways of reporting the insights by incorporating data analysis into the results made me realize this recursive nature of self-study (LaBoskey, 2004). It further helped me consolidate my understanding of the interactive dynamic nature of self-study.

Secondly, engaging in self-study in a CoP has a personal and educational value not only to the self-study practitioner but also those involved in the CoP. When I started with the PhD, I thought the learning is only for myself as I had to gain the knowledge for teaching pre-service teachers. I have come to realise that the learning was a reciprocal process that is situated in the CoP. Those who are involved in the professional community also tended to learn from the activities and

advance their professional development. This is not surprising as Martin and Dismuke (2015) note that a self-study of one individual can lead to hidden collaboration that is revealed through interpersonal relationships. This then suggests that self-study taken within the professional learning communities has the capabilities of influencing those who are immediate members of the community. Besides improvement of practice, the members of the CoP had started to show interest in the methodology of self-study. It is this interest that strengthened the CoP and the insights that I gained because they understood the complexities of dynamic nature of self-study.

## 8.8 RECOMMENDATIONS FOR FUTURE RESEARCH

The first main contribution to the field emanating from this study is the model of a novice teacher educator learning to teach pre-service teachers as set out in Table 8.1. The model shows that the 'self' can learn through different approaches that are based on reflection as a core tool. Although the model is developed from the teaching of a biology content course, the learning approaches are universal in the sense that any novice teacher educator can use this model to learn about teaching pre-service teachers. I recommend the testing of the model to see if someone else learning using the approaches outlined in the model would experience similar experiences to those recorded in this study. Testing the model may involve taking one aspect; e.g. looking at the differences in the practices of learning through exploration without borders and learning through focusing on the particular.

The second main contribution is the idea of professional judgement and practical wisdom. The study has demonstrated that as much as a novice teacher educator can learn about the pedagogies of teaching pre-service teachers, once they are given a full topic or module to teach, exercising professional judgement is necessary. The idea of learning to teach pre-service teachers and exercising professional judgement should help one to ultimately develop practical wisdom. This challenges the idea that teaching is a repetition of what one has learnt. In this regard, I recommend that self-study practitioners, especially novice teacher educators, can look into how they develop professional judgement and practical wisdom in building their professional identity. Practical wisdom is personalised and context-specific. As such, more research on the 'self' can shed light on how self-study can be a suitable methodological approach to study the development of one's practical wisdom. Furthermore, it is necessary, particularly looking at the specific shifts that one makes when drawing from the knowledge acquired. This would, in turn, shed light on the links

between theoretical and practical knowledge that one gains because there is no linear relationship between what is observed (including past experiences) and one's current behaviour.

### 8.9 FINAL THOUGHTS

At the beginning my PhD study, I got a question from one of the Professors; "Why not research other teacher educators and come up with a model of how one can teach pre-service teachers?" I did not have an answer to this question at that time. A similar question was asked three years into my PhD study. I can now answer the question in terms of the educational value of self-study. Self-study helps one to push boundaries that separate teaching and research as the research is within teaching and teaching lands itself in research. The on-job-training I did has significantly shifted my thinking about teaching in teacher education. I became aware of my thoughts, my actions, and pedagogy through reflection. This did not only require my intellectual but also the emotional commitment where I made public my vulnerability and uncertainties. This, in the end, transformed me into a better human being both personally and professionally.

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# 10.0 APPENDICES

## 10.1 APPENDIX A: THE ADAPTED INTERVIEW SCHEDULE AND MOTIVATION FOR THE INTERVIEW QUESTIONS

| Question from Nyamupangedengu & Mandikonza (2018) | Adapted questions | Reason for including the question |
|---|---|---|
| Describe a typical genetics lecture | Describe the LS population ecology content lecture session. | I wanted students to descriptions to give a description of the population ecology lectures they had with me. |
| Have you encountered formats other than a 'lecture'? | Have you encountered formats other than a lecture in the population ecology course? | To get the students' experiences of other content delivery methods in the population ecology course. |
| What sorts of content and skills have you encountered so far? | What sorts of content and skills have you encountered so far in the population ecology course? | To find out if they gained anything from the course including the content knowledge. |
| What messages about teaching and learning did you understand from genetics classes? | What messages about teaching and learning did you understand from the population ecology course? | To find out I was able to model practice and show them approaches to teaching the topic of population ecology. |
| How would you describe the 'level' of the work you have encountered so far? | How would you describe the 'level' of the work you have encountered so far? | To find out if the content and approaches were pitched at an appropriate level. |
| Can you describe any experiences of 'new' learning on the course so far? | Can you describe any experiences of 'new' learning on the population ecology course so far? | To find out if my teaching has made a contribution to the students' learning. |
| To what extent would you say you have enjoyed the course so far? | To what extent would you say you have enjoyed the population ecology course so far? | To find out from students if being involved in the course has made them enjoy and love science. |
| To what extent have you found the course useful so far? | To what extent have you found the population ecology course useful so far? | To find out from the students if what I taught and how I taught and designed the course would be of relevance to them. |

## 10.2 APPENDIX B: SUMMARY OF STUDENTS' DETAILS WHO WERE INTERVIEWED

| Student (Pseudonyms) | Gender | Number of lectures attended out of 6 | Year of study | Other subject and phase specialisation |
|---|---|---|---|---|
| Focus group 1 | | | | |
| Lebo | Female | 5 | 3 | Sesotho, Senior primary[19] |
| Ponelo | Male | 6 | 4 | Mathematics, Snr/FET[20] |
| Pearl | Female | 5 | 3 | English, Foundation phase |
| Teba | Male | 4 | 4 | PS, Snr/FET |
| *Focus group 2* | | | | |
| Jane | Female | 6 | 3 | Technology, Snr/FET |
| Hilda | Female | 4 | 4 | English, Senior primary |
| Debby | Female | 5 | 4 | IsiZulu, Snr/FET |
| *Focus group 3* | | | | |
| Leslie | Male | 4 | 4 | LS, Snr/FET |
| Drake | Male | 6 | 4 | Geography, Snr/FET |
| David | Male | 5 | 4 | PS, Snr/FET |
| Fatima | Female | 4 | 4 | English, Foundation phase |

[19] Senior phase is where among other subjects, learners do a combination of LS and physical science under the banner of NS (NS). This phase starts from Grade 7 to Grade 9.

[20] Further Education and Training phase[20] (FET) is Grade 10-12 level in South African schooling system. This is where learners specialize in their subject of choice, with physical science being one of the subjects of choice from Grade 10 (DBE, 2011)

## 10.3 APPENDIX C: DETAILS OF MY CRITICAL FRIENDS

**Group 1**

| Critical Friend | Occupation | Research interest |
|---|---|---|
| Jane * | A LS high school teacher with more than 20 years of teaching. | Science talk and how teachers incorporate learners' prior knowledge in their teaching. Reflection is integral to her as one of the participants in her study (element of action research) |
| Cilia* | Teacher educator in a university in Zimbabwe for more than 10 years. Cilia has taught the same course of population in the same institution I am teaching at. | Looks at how she teaches biodiversity to pre-service teachers for students to respond to environmental demands (Reflection is an integral part in her study) |
| Petronella* | LS high school teachers with more than 20 years of teaching | The use of drawings to teach LS |
| Bheki | Has taught PS for more than 20 years in Zimbabwe and South Africa | Studies how teachers use pedagogical link making in their teaching as a tool |
| Edon | A PS teacher for more than 15 years. | Studies learners' argumentation in PS classrooms |
| Aton | A PS teacher for more than 10 years | Looks at informal learning experiences of learners |
| Julie | A PS associate lecturer at Wits University | Looks at argumentation in pre-service teachers and how the pre-service teachers are able produce a correct scientific argument. |
| Nelly | Has been a LS teacher educator for more than 5 years in Nigeria | Looks at how students construct arguments in biology practical sessions |

*Subject experts in the topic of population ecology

**Group 2**

The second group of critical friends came from a research group of my second supervisor. They became my critical friends because they were all using a self-study methodology to study their practice.

Timmy – a LS teacher who is studying his practice of teaching evolution to address the common misconceptions.

Nyda – a primary school NS teacher studying how his teacher education programme prepared him to teach science.

Dona – PS teacher studying his questioning techniques in his teaching.

## 10.4 APPENDIX D: ETHICS CLEARANCE

**Wits School of Education**




27 St Andrews Road, Parktown, Johannesburg, 2193 Private Bag 3, Wits 2050, South Africa. Tel: +27 11 717-3064 Fax: +27 11 717-3100 E-mail: enquiries@educ.wits.ac.za Website: www.wits.ac.za

13 April 2017

Student number: 461653

Protocol Number: 2017ECE011D

Dear Climant Khoza

**Application for ethics clearance: Doctor of Philosophy**

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate, has considered your application for ethics clearance for your proposal entitled:

**Learning to teach pre-service teachers: A self-study**

The committee recently met and I am pleased to inform you that **clearance was granted**.

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely,

MMaseko

Wits School of Education

011 717-3416

cc Supervisor - Dr's A Msimanga & E Nyamupangedengu

## 10.5 APPENDIX E: PERMISSION FORM THE HEAD OF SCHOOL

21 April 2017

**RE: Permission to conduct my study at Wits School of Education**

Dear Professor Brodie

My name is Hlologelo Climant Khoza. I am a PhD student in the School of Education at the University of the Witwatersrand.

My PhD is based on the self-study methodology where I look at how I learn to teach pre-service teachers. A self-study is concerned with improving practice which is teaching pre-service teachers in this case. My research involves studying my own practice with the aim of understanding what it takes to plan and teach pre-service teachers. The issue is that I want to become a teacher educator but there is no training for new teacher educators. So I want to do on-job-training where I study my own planning and teaching in the Life Sciences III course. Therefore, the study can yield fruitful results in terms of how new teacher educators can train themselves to better teach pre-service teachers.

I therefore ask your permission to conduct my study at the Wits School of Education. Because my study is a self-study and I am looking at my practice of teaching, I ask for permission to teach a 3rd year Life Sciences content course. This is because I want to be a Life Sciences teacher educator. My teaching would be for a period of 3 weeks in Block 4. The teaching will also be under supervision of my supervisors Dr Msimanga and Dr Nyamupangedengu who will also act as my critical friends. So, both my planning and actual teaching would be discussed with my critical friends. The teaching will be video-recorded to capture all the incidences so that I can look at how I deal with content, students and context and how my teaching improves. I will also interview students to get their experiences about my teaching. I will request permission from students to video-record the lectures and conduct interviews. The focus is on me and not students *per se*. Therefore, students' interviews will just provide a lens of analysis of my teaching.

I have been granted ethics clearance for this study. The **protocol number is 2017ECE011D**

All the information will be treated according to the University's ethical policy on confidentiality. The study is being conducted for educational purposes and will cause no harm to the participants. The information that will be used in my write up from the participants will be reported so that their identity is anonymous. The results of the study may be published but the students' and school's identities will be anonymous. Everything that students say will be kept confidential by the researcher. The students will only be identified by a pseudonym in the transcript.

I am happy to discuss my study any further if that is required.

Yours sincerely,

Hlologelo Climant Khoza
0848734928
climantkhoza@gmail.com

Approved

Must take note of attached guidelines

## 10.6 APPENDIX F: LETTER AND CONSENT FORM FOR STUDENTS

Dear Student

My name is Hlologelo Climant Khoza and I am a PhD in the School of Education at the University of the Witwatersrand. Ethics clearance protocol number: **2017ECE011D**

I am doing a study entitled: "Learning to teach Biology to pre-service teachers: A self-study". This is my PhD study which is based on the self-study methodology where I look at how I learn to teach pre-service teachers. A self-study is concerned with improving practice which, in this case is my teaching of pre-service teachers. My research involves studying my own practice with the aim of understanding what it takes to plan and teach pre-service teachers. The issue is that I want to become a teacher educator but there is no formal training for new teacher educators. So I want to do on-the-job-training where I study my own planning and teaching in the LS III course.

I was wondering if you would mind participating in this study as a LS III student at Wits School of education. I would like to video-record the lectures so that I can go back and reflect on my teaching. The video-recording will focus on me. Only your voices will be captured in the recorder. I was wondering if I could interview you to get your experiences on my teaching. This is for me to learn from my practice. I need your help with interviewing you, video-recording our lectures and using some of your tests and tutorial scripts.

Remember, this is not a test, it is not for marks and it is voluntary, which means that you don't have to do it. Also, if you decide halfway through that you prefer to stop, this is completely your choice and will not affect you negatively in any way.

I will ensure anonymity by not using your own name but a pseudonym. Your test scripts will be given codes and your marks will be hidden. All information about you will be kept confidential in all my writing about the study. Also, all collected information will be stored safely and destroyed between 3-5 years after I have completed my project.

I look forward to working with you!

Please feel free to contact me if you have any questions

Thank you

Hlologelo Climant Khoza

807 Canary East Bank
Alexandra
2090

0848734928
climantkhoza@gmail.com

**Student Consent Form**

Please fill in the reply slip below if you agree to participate in my study called: Learning to teach Biology to pre-service teachers, a self-study

My name is: _____

| | **Circle one** |
|---|---|
| **Permission to review/collect documents/artifacts** | |
| I agree that my tutorial and test scripts can be used for this study only. | YES/NO |
| . | |
| **Permission to be audiotaped** | |
| I agree to be audiotaped during the interview | YES/NO |
| I know that the audiotapes will be used for this project only | YES/NO |
| **Permission to be interviewed** | |
| I would like to be interviewed for this study. | YES/NO |
| I know that I can stop the interview at any time and don't have to answer all the questions asked. | YES/NO |
| **Permission to be videotaped** | |
| I agree to be videotaped in class. | YES/NO |
| I know that the videotapes will be used for this project only. | YES/NO |

**Informed Consent**

I understand that:

- my name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- I can ask not to be audiotaped, photographed and/or videotape
- all the data collected during this study will be destroyed within 3-5 years after completion of my project.

Sign_____ Date_____

## 10.7 APPENDIX G: AN EXAMPLE OF AN INITIAL CODING OF A TRANSCRIPT FROM DISCUSSION WITH EXPERIENCED TEACHER EDUCATORS

| Speaker | Utterances | Assigned possible quote |
|---|---|---|
| **I** | So, the big question is how do you prepare for lectures? | |
| **Rose** | So, I am going to just talk because this year I have only taught Reproduction to the Be.Ed fourth years | |
| | So, if I think how I develop the course, then I can talk about preparing for lectures because it conceptualises everything | Course outline first |
| | So, I have taken the whole topic of reproduction | Topic – content knowledge?? |
| | and I looked at what is done at school level | School curriculum – content knowledge/curriculum knowledge 2nd level?? |
| | to make sure that the students who are going to be teachers are covering basic concepts at school level | School context – knowledge of context 2nd level?? Knowledge of students |
| | And then I have looked at what I being done at university | University content – first level CK?? |
| | Using textbooks and I have looked at the sort of depth that they go into in different tertiary level textbooks, so I have used that as a guide | Textbooks as source of CK; as determinant of CK depth 1st level CK?? |
| | I have no looked at other institutions to see what they actually do | Comparing institutions' CK; determinant of depth |
| | I have tracked the topics covered in reproduction | Topic sequence - Curricular saliency?? |
| | and slipped them up into lectures all the way through | Topic/concepts sequence – curricular saliency?? |
| | So I have taken...In addition, I go beyond what is at school level and I start off with the historical side of the discovery of reproduction and how it took place. So my first lecture is dealing with that because I want to have some sort of sense of the history that it is about what we know now. There has been the whole process of centuries and centuries to discover reproduction. | History of 1st level content; sequencing (curricular saliency) |
| | So, that is the first thing. And I look at different concepts and pack them up for each lecture. So, I have topics on meiosis related to spermatogenesis. Oogenesis, male and female reproductive cycle, etc. And then I take my seven weeks and start to allocate topics. | Concept sequencing – curricular saliency |
| | And I look at how it gets applied into people's everyday lives. I look at different diseases, things that can go wrong and all that. | Content relevance to students |
| | Then that is...I need to have topics first, I have to have concepts of what I want to cover in that topic.<br><br>So, then I start to dot down key points and key ideas that I want to cover in that lecture | Course development and sequencing<br><br>Concepts then ideas |
| **I** | So, when you said you look at tertiary textbooks, what kind of textbooks, what guided your choices? | |

| | | |
|---|---|---|
| **Rose** | So, Campbell and Reece was a very useful textbook, I have got Raven...I have a whole range of textbooks there that you can have a look at | Textbook choice, textbook as source of content |
| | So, I looked at them but some of them...for example, Campbell and Reece, when they go into embryology, it goes into too much detail for 7 weeks that I have got. So, I take it and I actually simply. So, in Campbell and Reece, embryology would probably take about 3 weeks to teach and I don't have that sort of time | Context versus content coverage |
| | So, I have to look at it and say what information is most relevant and most useful to my students. So, for example they go into other animals' embryology and I focus on human embryology. | Content relevance – knowledge of students and student identity?? |
| **I** | So, you said Campbell and Reece went into details and... | |
| **Rose** | Yah, some of the textbooks go into too little detail. So, it is really for my choice. So, I make a choice as a lecturer on | Autonomy |
| | based on my experience on the number of years. On how much I can put into that 7 weeks and what sort of detail I can go into that 7 weeks | Role of experience |
| | And every year I modify it | Role of reflection |
| | Sometimes I think I have gone into too much detail or too little detail and I move my lectures around, the order | Role of reflection on concept sequencing |
| | So, I am continually rethinking the structure of the course and how I develop these concepts | Role of reflection |
| | How do you go from known to what is not known. How do you go from the matric level maybe too much greater depth that would be most appropriate for 5th year level? | Concept sequencing approach |
| | But not the depth that would become something else...I have to fit that into 7 weeks. | No depth due to time<br>Time knowledge of context?? |
| **I** | So, are you saying that it is because of time? If you had time, you would go into much details? | |
| **Rose** | I am not sure if I would. We have decided as a group | Role of other teacher educators |
| | that...so for example, I teach embryology for 1 to 2 weeks. Well I showed students what I did in second year which was six months on embryology and I had a fat book on it and I said "Because I did 6 months on embryology, there are topics that I did not do. So, I am not going into details but if you are interested, Campbell and Reece has got a lot more details, read it on your own but I am not going into that much detail" | Role of experience |
| | So, I had to make a choice | Teacher educator's autonomy |
| | and this is what we have done as a Biology group. So we sit down and discuss what topic to leave out and what topics to include at third and 4th year level | Role of other teacher educators |
| | So, we thinking of them going out to teach this. | School curriculum<br>2nd level CK/Context? |
| | So we want to do is to take the school topics and expand them to give the students a much bigger picture around those topics | Broaden the topic |
| | So, we don't go into topics that we feel they are not necessary | Relevance of concepts |
| | That is why I wouldn't go into deep embryology because they are looking at embryology of worms, chicks so we are not interested in that | Go broad than deep |
| | That is why this is very much different from a Bsc degree because in that you become very, very focused on certain topics | Comparing fields –<br>1st level context? |

| | | |
|---|---|---|
| | So, if you were genetics, it is all you do and here they have 1 term of Genetics. Instead of a whole year of genetics with 2 pracs a week and 6 lectures a week for the whole year...So, there is a vast difference in the focus. We go broader and in a degree you go deep in a particular focus | Go broad than deep |
| | because you want people to become specialists and find their career in that particular focus. | Relevance of content to students |
| **I** | So, how do you choose the textbooks? What guided your choice? | |
| **Rose** | We, chose Campbell and Reece because it is used very widely across the institutions in SA. It is an American textbook, a good quality textbook. But we felt, we are not going to continue with it because it is too detailed and too expensive. What we are switching to is another textbook which we think is accessible and for students who are not going into very, very details. So, we used another textbook as a guide so said no, they don't need to spend so much money on the textbook | Textbook choice as source of CK |
| | We would like to have a textbook that is more user-friendly | Relevance of material to students |
| **I** | Campbell is a good book for a lecturer to have? | |
| **Rose** | It is a very good book for lecturers and very good book for the students to have. Because what we want them to do is go out and teach and have a reliable source of information. So different chapters are written by different authors who are well known in their field. So it is not just written by anyone. It is written by experts in the field. | Relevance of material to students |
| | So, we are looking for expertise, quality and a book that is well written out. And, there were other books at we looked at. | Choice of textbook |
| **I** | So, let us say in terms of me; I am supposed to teach population ecology. But I have done population because in fact LS is my subject major. I majored in maths. So I did very limited topics. So, how do you suggest I go about because my knowledge of Biology is limited and I haven't done it. How far should I go for my own reading of population ecology? | |
| | So, I think for your own reading, you have to go as deep as you can because some of those students will know about those topics. | Teacher educator has to read to the depth |
| | My students knew plenty about reproduction | Student prior knowledge |
| | because they had their own children. They watch YouTube moves, they have been reading | Student source of prior knowledge |
| | I think first of all, you need to look at the school curriculum… what are the basic concepts' so | School curriculum |
| | Well that is what I do and say 'I think you should go into a series of different textbooks. So, let me clear about that: although Campbell and Reece is the prescribed textbook, I did not just look at their book. I worked with around 4 or 5 different textbooks. And sometimes there is something in one book that I think will be important to inform students about. So, I will add it. I keep getting new ideas | Have different sources of content knowledge |
| | When I started teaching reproduction, for example, I did not teach about the different diseases like hiv and aids | The role reflection |
| | And I asked aren't you taught about this diseases when you do viruses and they said no | Student prior knowledge |
| | about two years ago, I brought that in and we started to look at immunity in the course of reproduction and what makes you immune and how does HIV overcome that immunity. We started to go into different types of cells and | Role of experience and reflection |

| | | |
|---|---|---|
| | the whole issue of immunity. So, you know you start to network outwards and you need to | |
| | continue… as you read the books, you need to network; look at internet sources, YouTube videos and get different ideas | Sources of teaching ideas and content |
| | So, I would start with the basic plan of what they need to know at the school level. | First gather content knowledge |
| **Rose** | And from that I would draw little mid maps and then I start to think about how I could fit that into different lectures | Sequencing of concepts – curricular saliency |
| | Then I look at the variety of different textbooks because those textbooks are used in colleges and universities around the world | Textbooks as source of content knowledge |
| | I look at what they cover and I say to myself; 'what is appropriate that would enlarge and expand students' ideas | Autonomy in determining depth and broadness; student prior knowledge |
| | So what are the different ideas that can expand their understanding of population dynamics | Student prior knowledge |
| | And I look at what the textbooks are saying that is not applicable in the context of South Africa | Relevance of content to students |
| | For me, reproduction was an easy one because students want to know about contraceptives. | Relevance of content to students |
| | And when you teach that, there are so many questions that you realise you may need to deal with that in-depth in the following year. So you are learning from year to year and you are changing lectures every year. | Role of teacher educators' experience, autonomy and reflection |
| | I mean it is an advantage of putting things on power point | Importance of PowerPoint as an instructional material |
| | And you can change that just after the lecture for the following year while it is still in your memory. I mean if you want to know, pull out a book from there and then we will look at population dynamics. Pull out Campbell and Reece and the book below…[Looking at the two textbooks] | Role of teacher educators' reflection |
| | And one of the things that you need is to know what they have done beforehand. What can you build on? | Role of Student prior knowledge |
| | When I look at this textbook, it is all about human population…[reading out main topics from the textbook]. So, I would take some of the interesting ideas here | Textbook as source of content |
| | And then if you come to here (Campbell and Reece), they would have a much more comprehended version [Looking in the textbook]. You see this is much more comprehensive. So, this is going to be more useful to me…so what this is doing is that focuses on Biology in general and that is focusing on human Biology. You see I would use this book as a guide because it is telling me about some of the key concepts in population dynamics and not going into too much details and students have this | Textbook as source of content |
| | I would start to map out the key concepts. | Concept sequencing (tool) |
| | And I suppose have been teaching for a very long time and I have gut feel fo what is appropriate at school, first year level and fourth year level | Influence of student level on content choice |
| | That is the purpose of working in a team and working with other people | Role of other teacher educators |
| | So, for me, I would make sure that I firstly that I understand this topic very well. So you can't go into teaching the subject without having the real sense of what is the | Gathering content as first step |

| | | |
|---|---|---|
| | scope of the subject and I would start to break up and say how many lectures do I have, how many tuts and how many pracs. What am I going to do in the tuts and pracs? | Sequencing of concepts<br>Coverage of content in different teaching platforms |
| | Are the tuts elaboration of the lectures? | Sequencing - Link of teaching platforms |
| | What am I going to do in the pracs? Am I going to be modelling things? Am I going to play around with beads to model? You have to thick about the pracs that you can do. I don't know if that helps? | Teaching approaches and methods |
| **I** | Yes it does helps a lot. | |
| **Rose** | So, let me get you to pull out another book. So this is another Biology book Raven and Johnson [Looking in the book together] We had a conversation on how the textbooks are structured. | Nature of textbook |
| **I** | It is more or less structured like the Campbell one. I am just looking at the key concepts | |
| **Rose** | Let's have a look…this looks even more useful. It started at a global level…[paging through the book] so they are dealing with big concepts like population dispersion. | Sequencing of concepts in the textbook |
| | You have to decide if you want to use all these models and formulas | Teacher educator autonomy |
| | And this is something you can use in pracs .You give them formulas and they calculate things…so what you are finding is that people | Textbook as source of teaching methods and activities |
| | because they go to conferences around the world, they say what the important concepts are and then include those in their books. So that is why looking in the books gives you a sense of what other people are doing in different places around the world. | Textbooks as source of global content knowledge |
| | What you can do is plot out what these different textbooks do. So, I read thoroughly and get a sense of everything. | Gathering content as first step |
| | When I was doing endocrine system for the first time, I actually took previous slides and looked at what he did and I was not crazy about it. So, I just added and changes some things | The role of previous teaching material |
| | I looked at textbooks and how they represent things. Scanned lots of pictures and used them in my power points. | Textbook as source of teaching and learning aids |
| | It is an ongoing process at a tertiary level. | Role of reflection |
| | It is not like at a school level where you have syllabus specified. You have to actually develop and use your own initiative. | Teacher educator autonomy |
| | That is why is very important to consult different textbooks to see what are the key concepts to understand population dynamics<br>I am just thinking that reading is one thing and attending somebody's lecture is another thing. So, I don't know if it can work…maybe in Block 3 there is somebody teaching population ecology at main campus and I just go and attend. | Textbooks as source of content<br><br>Learning platforms for teacher educator |
| | That could help you but you will have to find out if there is anyone. Did anyone teach population ecology before? It is always useful to see what someone has done before you. | Role of previous material |
| **I** | Yes it was Dr… | |
| **Rose** | So, what did she teach? Has she got her power points? | |
| **I** | At some point yes she did but I haven't looked at that yet | |
| **Rose** | Have a look at that and decide how you want to do it, it is really up to you… …Okay…good luck!! | The role of reflection |

| | | |
|---|---|---|
| | there is no recipe…but you cannot just replicate her stuff | Teacher educators' autonomy |
| | It is a learning curve, your plan changes every year because of students and other funny stuff but | Influence of type of students and context |
| | you need to also have some kind of framework, like what guides your decisions | Role of theory/reasoning |

## 10.8 APPENDIX H: LIST OF FINAL CODES FROM TRANSCRIPTS ON FORMAL DISCUSSIONS WITH THE EXPERIENCED TEACHER EDUCATORS

| Code | Description of code |
|---|---|
| Course outline | Described any reference to the development of the course as a whole |
| Topic | Describes mention of a topic of biology |
| School curriculum | Any description that points to the school curriculum or syllabus followed in schools |
| Students as teachers-identity | Describes the pre-service teachers as future teachers or their identity of being teachers |
| School level content | Any reference to the content in school level; content found in school curricular or syllabuses |
| University content or university curriculum | Any reference to the content for university students |
| University textbooks to determine content depth | Describes how the content in the university textbooks influences choice of content for pre-service teachers |
| Textbook | Points to the nature of the textbook chosen and how it is chosen |
| Curricular of other institutions | Describes connection of the university content to the content of other institutions |
| Curricular saliency | Describes sequencing of concepts and decisions about what to teach first and last |
| Course duration | Described the time given to a course as a factors in decision making |
| Content relevance to students' everyday lives | Any description that points to the usefulness of content and teaching materials to pre-service teachers' everyday lives |
| Teacher educators' autonomy | Any description that points to how the teacher educators exercise their powers in making decisions during planning |
| Role of experience | Anything that refers how the teacher educators draw from their experiences |
| Planning as a continuous exercise | This is when the teacher educators referred to planning as a continuous process; from year to year |
| Role of reflection | Describes anything that points to decisions made on the basis of reflection |
| Student prior knowledge | Describes the role of student prior knowledge in the decisions that the teacher educator take during planning |
| Modelling practice | Describes any references to showing students effective practices of teaching |
| Teaching approaches and methods | Describes techniques and methods about teaching biology including instructional strategies |
| School context | Any description of the context of the school including the resources that the pre-service teachers are likely to find |
| University context | Any description that points to the context of the university like infrastructure |
| Content delivery methods | Any reference to the platforms where learning takes place; practical and tutorial sessions |
| Assessment | Describes practices that point to assessing students and assessment strategies |
| Role of other teacher educators | Any description that points to how a teacher educator consults others |
| Content depth/breadth | Any description of how deep or broad the teacher educators would plan to teach their content |
| Student skills | Describes the skills that students need to be equipped with in a content class |

## 10.9 APPENDIX I: COMPARING CAPS AND IEB IN THE TOPIC OF POPULATION ECOLOGY

| Aspect of differentiation | CAPS | IEB |
|---|---|---|
| Overall organisation | Shows time, topic, content, investigations and resources in columns. Under topic, there is 'population ecology'; under content, it shows what I could term 'sub-topics' or 'big concepts'. The document prescribes investigations and resources that can be used to teach the topic. | Shows specific aims in columns in this order: Specific Aim 2, 1 and 3. Under specific aim 2, it shows "opportunities to demonstrate research skills"- similar to investigations in CAPS. Under Specific aim 1, it shows the "population ecology" and organised under the phrase "learners need to know..." Under specific aim 3, there are prescribed activities which show application of LS to the society. |
| Level | Grade 11 Term 2 | Grade 12 Term not specified |
| Strand | Environmental studies | Environmental studies |
| Topic | Population ecology – under the column of topics | Population and community ecology – written just under the strand |
| Investigations/Activities | Determining population size by quadrant or simple sampling (simulated mark-recapture)<br>Case study – rationale for culling (elephants in Kruger National Park)<br>Draw public survey to form to test the public opinion about culling.<br>Draw a life cycle of a bilharzias parasite<br>Identification and study an area where succession takes place | Ecosystem study or study of a local environmental issue.<br>Investigate community structure within a habitat and its changes<br>Sampling methods (Select 1)<br>Use of field guides for identifying species<br>Interpretation of population graphs |
| Resources | Textbooks, reference books, posters, charts, brochures, DVDs, Newspapers, Magazines, Watching nature programmes on TV | No mention of resources |
| Duration | 4 Weeks (24 hours) | No mention of duration |
| Weight in examination | 24% (36 marks) – Weighs more in P1 | Not mentioned |
| Concepts I identified | Population size<br>Immigration and emigration<br>Fluctuations<br>Mortality and births<br>Geometric growth; different phases<br>Logistic growth<br>Limiting factors and carrying capacity<br>Environmental resistance<br>Interactions in the environment<br>Predation<br>Competition<br>Specialisation | Population size<br>Effects of limiting factors<br>Density dependent/independent factors<br>Environmental resistance<br>Carrying capacity<br>Sampling methods<br>Mark-recapture<br>Quadrants<br>Census<br>Random<br>Predator-prey relationships (lion-zebra; aphid-ladybird) |

| | | |
|---|---|---|
| | Parasitism<br>Mutualism<br>Commensalism<br>Social organisation<br>Castes<br>Dominance<br>Packs (hunting)<br>Herds (avoidance)<br>Succession (primary and secondary)<br>Human population (age-gender distribution) | Food webs and social organisation (impact on population)<br>Competition, ecological niche<br>Resource partitioning (forests), Co-existence (shoebirds; lions and leopards) [ways of reducing competition]<br>Ecological succession (primary and succession)<br>Social organisation (herds/flocks)<br>Human population |
| Links to other topics | Link parasitism (Bilharzia) to animal biodiversity | No explicit links mentioned |
| *Other | | Emphasis is put on debates and reflections (Specific Aim 3)<br>- Debate decision to intervene and control community structure (elephants culling)<br>- Discuss and debate human influences on succession (fire)<br>- Debate issues around human demands and conservation of natural environment (human requirements for land versus conservation; the hunting industry; sustainable harvesting of natural resources; creation and management of game reserves).<br>- Reflect on aesthetic value place on SA's biodiversity by people.<br>- Implications of further human population growth<br>- Ecological foot print of people in developed countries versus developing countries |

## 10.10 APPENDIX J: A TABLE OUTLINING THE BREAKDOWN OF CONTENT FOR PRE-SERVICE TEACHERS FOR THE FIRST WEEK

| Date and lecture (s) | Big idea | CAPS and IEB content | More content |
|---|---|---|---|
| `Monday18/09 – single lecture | Populations exhibit density, dispersion and demographics. | Density is the number of individual's pre unit area. And dispersion is the pattern of spacing among individuals. Population density is affected by migration, natality and mortality. Emigration and mortality decrease the population size whereas immigration and natality increase the population size. Different methods are used to estimate the population size. Some of these methods include quadrants method where a plot of an appropriate size is used and census that is mostly use to count the population of human beings. The most used one in some animals is mark-recapture method. In this method, a random sample is captured and marked using an appropriate technique like painting or tag, then the sample is released to mix with other individuals for a certain period of time which lasts for days or weeks. A second set of individuals is sampled after that duration. This method is mathematically defined as the number of marked animals captured in the second sampling (x) divided by the total number of animals captured in the second sampling (n) equal to the number of individuals | Dispersion<br>Populations show different dispersion patterns due to several reasons. Random dispersion which is unpredictable is shown when individuals are independent of other individuals in a pattern. In this dispersion, there is no attraction or repulsion amongst individuals. An example would be dandelions that germinated from seeds which are windblown. Uniform dispersion is when populations are evenly spread and results from interactions between the individuals of the same population. For example, some plants secrete certain chemicals which inhibit germination and growth of nearby individuals. In animals, there is antagonistic interaction where some animals exhibit an aspect of territoriality. Clumped dispersion is the one which is most prevalent in nature. Individuals are aggregated in patches in response to availability of resources. For example, insects being clumped under a tree because of nutrients there or flock of birds to serve as a defence mechanism. So, there are three factors that contribute to clumping of individuals: responding to local habitat; responding to daily or seasonal weather changes; reproductive processes and social interactions.<br>Demographics<br>Demography is the quantitative study of populations and how the size of populations change over-time. These statistics are summarised using life tables which are age-specific summaries of the survival pattern of a population. These life tables are developed from a cohort which is a group of individuals of the same age from birth until all of the individuals are dead. Life tables then give rise to survivorship curves (see Appendix 1 regarding an explanation of life tables and survivorship curves). Reproductive rates are also used by demographers to study the size of populations in sexually reproducing species. They therefore focus on females since they are the ones giving birth. Reproductive tables show age-specific summary of reproductive rates in populations and constructed by measuring the reproductive outputs of a cohort from birth until |

| | | | |
|---|---|---|---|
| | | marked and released in the first sampling (s) divided by the estimated population size (N).<br>*Nothing on dispersion<br>*Nothing on demographics but a mention on survivorship curves in relation to K-selection and r-selection. | death. High reproductive rate does not necessarily lead to rapid population growth since there are factors which affect the survival of individuals in populations (See Appendix 2 for an example of reproductive table and explanation). |
| Friday 22/09 – Single lecture then tutorial | There are two models (exponential and logistic) that are used to describe population growth. | Geometric and Logistic growth curves with phases<br>The geometric growth form is J-shaped. The population grows rapidly. The graph would show a flat shape where there is little or no growth because the population is still getting used to the new environment. The population then grows rapidly because of abundance of resources and because there is lack of limiting factors to hinder population growth. In the logistic form, there are four distinct phases. The first phase is called the lag/establishment phase where the population grows very slowly because the organisms are getting accustomed to the new environment. The second phase is called the geometric/logarithm phase where the population size increases rapidly since there is little or no limiting factors. The third phase is called equilibrium/stationary phase which is usually the final phase. This is where the population growth slows down because the increased | The concept of per Capita rate of increase.<br>If N represent population size/number or organisms and t represents time then to determine the growth rate of particular population we need to look at the average growth rate in the number of organisms per time therefore $\frac{\Delta N}{\Delta t} = B - D$. This equation does not help us to predict the number of births and deaths. We then use per capita concept which tells us the average number of births and deaths per individual. Therefore per capita rate of births is the number of offspring produced per unit time by an average member of population.<br>Example: There are 32 births per year in a population of 1000 individuals. Determine annual per capita birth rate and the expected number of births per year when the population has 500 individuals<br>$b = \frac{34}{1000} = 0.034 \; and \; the \; birth \; rate \; will \; be \; B$<br>$= bN = 0.034 \times 500 = 17$<br>The same thing applies to deaths. So, D would tell us the expected number of deaths per unit time in a population of any size.<br>To get the rate of increase or decrease, we use a calculus concept of instantaneous rate that explains population growth at a particular instant time. This is given by the formula<br>$\frac{dN}{dt} = r_{inst}N; r = b - m$<br>When r is greater that 0, the population is growing and when r is less than 0, the population is declining and there is Zero population growth when r equals 0.<br>The logistic model<br>The difference in exponential and logistic growth is that logistic growth shows reflect the concept of carrying capacity. So, is carrying capacity is represented by K, then K-N is the number of individuals the environment can support. Therefore |

| | | | |
|---|---|---|---|
| | | population density has increased the effect of detrimental factors therefore environmental resistance increases. The last phase is death phase and it is not always present. This is where conditions become unsuitable for the population and then the population size drops. | (K-N)/K is the fraction of K that is still available for population growth [The concepts of maximum and optimum carrying capacity]. Therefore the logistic growth is modelled by $\frac{dN}{dt} = r_{inst}N\left(\frac{(K-N)}{K}\right) where\ r_{inst} = 1.0$<br>When N is small compared to K, the fraction of K is close to 1 and per capita of increase approaches the maximum rate of increase. When N is large and the resources are limiting, then fraction of K is approaches 0 and per capita of increase is small. When N equals K, then population stops growing (See Appendix 3 for the graphs and tables showing the models of a hypothetical population) |

## 10.11 APPENDIX K: AN EXAMPLE OF CORE FOR THE FIRST THREE PROMPTS

| Prompts | | **Big Idea 1:** Populations exhibit different patterns of dispersion, density and demographics | **Big Idea 2:** Exponential model and logistic model describe the growth of populations. |
|---|---|---|---|
| What do you intent students to learn about this idea? | Standard Content | Density refers to population size per square metre. Population size can be determined by using different methods like mark-recapture method. Demographics study populations and how the size changes over time. This is explained by diagrams like survivorship curves tables like life tables and reproductive tables. | The geometric/exponential model explains population growth without limiting factors and environmental resistance. Logistic model takes into consideration environmental resistance and carrying capacity |
| | For teachers (Extra content) | Demography is the quantitative study of populations and how the size of populations changes over-time. We have three patterns of dispersion: clumped, random and uniform. These statistics are summarised using life tables which are age-specific summaries of the survival pattern of a population. | Both these models can be used to calculate per capita rate of increase to see how the population increases (calculations of population growth) |
| Why is it important for students to learn this? | Dispersion pattern is one of the key characteristics of populations because it provides the ecologists with important information regarding environmental associations and interactions of individuals in the environment. So inclusion of the concept of dispersion will help students understand why populations exhibit certain behaviour.<br>the school curriculum only goes to the level of estimating the population size.it is important to mention to pre-service teachers that demography is aligned to population sizes. Although learners are supposed to learn about the population size, they also need to be aware that population size is not static! Equipping pre-service teachers with the concepts of life tables, sex-ratio and survivorship curves give them more content to justify to their learners why populations changes through time. | | The curriculum only wants learners to learn about the population size and understanding how emigration, natality and mortality affect population growth. So, the focus is on the population size and not rate of increase. I want my students to have more knowledge than that. I want them to understand how ecologists work so that they can make this explicit to their learners. I want them to be able to determine the rate of increase for both the exponential and logistic growth curves. Working with the equations and modelling the population growth will develop students' scientific skills and improve their feeling of fitting into the scientific community as opposed to just being students.<br>In order for students to understand that the carrying capacity is not static, they need to understand that there is optimum |

| | | |
|---|---|---|
| | | carrying capacity where the environment can still take more of the individuals (implications for the fraction of K) and maximum carrying capacity where the some individuals would not survive because the habitat has reached maximum support. |
| What else do you know about this idea that you do not intent students to know yet? | Calculating different components of the life table and reproductive table and interpreting them.<br><br>The concept of meta-populations and the effects of their interaction. Students do not need this concept to be able to understand another important concept | N/A |

## 10.12 APPENDIX L: DETAILED PROGRAMME FOR POPULATION ECOLOGY TOPIC

| POPULATION ECOLOGY | | |
|---|---|---|
| Week 1 | Mon 18 Sep | Lecture: Introduction to population ecology; characteristics of populations (MU230) |
| | Wed 20 Sept | Prac: Determining the population size using simple sampling and mark-recapture method |
| | Fri 22 Sept | Lecture: Models of population growth (MU230) AND Tut: characteristics of populations and estimating population size (Labs) |
| Week 2 | Wed 27 Sept | Lecture: Factors affecting population growth and life history adaptations (MU230) |
| | Frid 29 Sept | Lecture: Interactions in the environment (MU230) AND Tut: Preparation for presentations (Labs) |
| Week 3 | Mon 2 Oct | Lecture: Human population growth (MU230) |
| | Wed 4 Oct | Prac: Investigating population growth using simulations (Glass lab) |
| | Fri 6 Oct | Student presentations (Labs) |

## 10.13 APPENDIX M: PLANNED AND ADMINISTERED TUTORIAL ACTIVITIES

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# Division of Science and Technology Education

**LS III (EDUC 3108) POPULATION ECOLOGY TUTORIAL 1 – 22 SEP 2017**

This tutorial is designed to help you consolidate your understanding of the concepts of density, dispersion, and demographics. In order to earn credit for this tutorial, you need to **actively participate** during the tutorial and also **hand in your answers** at the end of the tutorial session.

1. To assess how populations in nature are changing, ecologists use life tables. What is the main aspect that a life table shows?
2. Life tables are generally divided into ‘females’ and ‘males’. Why is this necessary?
3. Draw the most likely survivorship curve for a particular fish species where each female produces millions of eggs per year. Give a brief explanation for your choice of the survivorship curve.
4. Briefly describe three types of dispersions shown by populations. Which one is prevalent in nature? Explain your answer.
5. The following shows a reproductive table for Belding’s ground squirrels. Explain the trends that the data in the table shows.

**Table 52.1 Life Table for Belding Ground Squirrels (*Spermophilus beldingi*) at Tioga Pass, in the Sierra Nevada Mountains of California***

| | Females | | | | | Males | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Age (years) | Number Alive at Start of Year | Proportion Alive at Start of Year | Number of Deaths During Year | Death Rate† | Average Life Expectancy (years) | Number Alive at Start of Year | Proportion Alive at Start of Year | Number of Deaths During Year | Death Rate† | Average Life Expectancy (years) |
| 0–1 | 337 | 1.000 | 207 | 0.61 | 1.33 | 349 | 1.000 | 227 | 0.65 | 1.07 |
| 1–2 | 252†† | 0.386 | 125 | 0.50 | 1.56 | 248†† | 0.350 | 140 | 0.56 | 1.12 |
| 2–3 | 127 | 0.197 | 60 | 0.47 | 1.60 | 108 | 0.152 | 74 | 0.69 | 0.93 |
| 3–4 | 67 | 0.106 | 32 | 0.48 | 1.59 | 34 | 0.048 | 23 | 0.68 | 0.89 |
| 4–5 | 35 | 0.054 | 16 | 0.46 | 1.59 | 11 | 0.015 | 9 | 0.82 | 0.68 |
| 5–6 | 19 | 0.029 | 10 | 0.53 | 1.50 | 2 | 0.003 | 0 | 1.00 | 0.50 |
| 6–7 | 9 | 0.014 | 4 | 0.44 | 1.61 | 0 | | | | |
| 7–8 | 5 | 0.008 | 1 | 0.20 | 1.50 | | | | | |
| 8–9 | 4 | 0.006 | 3 | 0.75 | 0.75 | | | | | |
| 9–10 | 1 | 0.002 | 1 | 1.00 | 0.50 | | | | | |

*Males and females have different mortality schedules, so they are tallied separately.
†The death rate is the proportion of individuals dying in the specific time interval.
††Includes 122 females and 126 males first captured as one-year-olds and therefore not included in the count of squirrels age 0–1.

SOURCE: Data from P. W. Sherman and M. L. Morton, "Demography of Belding's Ground Squirrel," *Ecology* 65(1984): 1617–1628.

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6. Mark-recapture method is one of the methods used to estimate the population size. Its important assumption is that marked individuals have the same probability of being captured as unmarked individuals. Describe a situation where this assumption might not be valid and explain how the estimate of population size would be affected.

## LS III Population Ecology

## Tutorial 2– presentations on population growth issues.

### Background

Human population is continuing to increase. This has drawn population ecologists' attention. Some analysts claim that the consequences of increasing human population put forward are myths. For example, Jim Peron published a book in 1995 where he explores some of the population myths (Peron, 1995).. Some claim that the increasing human population growth will lead to the 6$^{th}$ mass extinction. It is somehow clear that increasing human population growth has consequences to the environment. The 2016 data world population data sheet revealed that the world population is 7.4 billion with 526 average global population per square kilometre of arable land - 239 in more developed countries and 697 in less developed countries.

**What you need to do**

In this activity, we will engage in relevant material to understand human population increase, its consequences and what overpopulation means. In groups of no more than 6, you will be given a scenario to analyse and prepare a 10 minutes presentation, role play or any other method you can think of. The method you choose should clearly address the scenario. At least half of your group members need to take part in the presentation.

Each scenario has guiding questions. However, you are not restricted to those questions. Remember the objective of this activity to help us understand human population growth, its consequences (if any) and possible solutions. Because of time, no group will be able to address all of these. Therefore, each group will be given a scenario that speaks to one or two of the above aspects.

**Assessment**

You will be assessed by your peers and your tutor using the same rubric. Your tutor will randomly hand-out 4 copies of the rubric to your fellow students (individually) before your group starts presenting. The final mark will be decided by your tutor taking in consideration how the four individuals graded your group.

**Scenarios**

A

The human population gas reached 7 billion. Some people would celebrate for this and others would start to get worried and deem this as a threat to the survival of people.

1. Why should (shouldn't) we fear population growth?
2. Discuss reasons (if any) for population growth and against population growth
3. Should we get worried? What is our role in this regard?

B

Population growth accelerated in the middle of the $18^{th}$ century because of industrial revolution and other improvements in agriculture. The rate of increase has declined lately. Africa still remains as a continent with a large population size.

1. Trace the global human population growth and account for the trend.
2. Account for the differences in population densities for different continents and/or countries.

C

Throughout the world, living standards are improving. Birth rates are declining and population growth is steadily coming to a halt –with one exception: Africa. African countries are forced to do with less and less food each year while their populations continue to expand.

1. How true is the second statement? Find relevant data to support your argument.

D

One of the ways of explaining overpopulation and overcrowding is reasoning from food production perspective. It is argued that food production continues to exceed population growth in many countries. Also, non-renewable resources seem to become more plentiful each year.

1. How true is the second and third statement? Find relevant data to support your argument.
2. What are the alternative ways of explaining overpopulation or overcrowding?

E

In poor countries, children are often seen as a retirement plan. Parents need someone to provide for them in their old age and children are the means to this end.

1. Does the above statement hold in the present days? Did it hold before?
2. What are (were) the effects of having many children?

F

In 1979, the government introduced the one-child policy, under which most couples are allowed to have only one child or else face the possibility of fines, sterilizations, and abortions. The Chinese government tried to force a Chinese woman, studying with her husband in the United State to have an abortion. The woman was pregnant with her second child received a letter from the population control office of the Manchurian factory where she had previously worked. The letter said "The punishment for this kind of violation is very severe and we strongly advise you not to risk it. If you cannot have this abortion done abroad then the factory director orders you to return to China immediately. Any further delays and you will be punished according to the law. There is nothing about out order. Make up your mind immediately!"

1. On what conditions did China introduce the law? Was it a fair law?
2. What effects did this law have in China and Globally?
3. Was the letter written

**Rubric**

| *Criteria* | ***A. Inadequate*** | ***B. Adequate*** | ***C. Good*** | ***D. Excellent*** |
|---|---|---|---|---|
| *Unpacking the scenario, identification of the 'problem' and formulating the bigger question (s) around the scenario.* | 0-4 | 5-6 | 7-8 | 9-10 |
| | Does not identify the 'problem' or the question (s) embedded in the scenario. The scenario is rarely unpacked. | The student only relied on the guiding questions and tried to answer the questions. | The question (s) and/or 'problem' capture the scenario very well. There is evidence of engagement with the activity. | As in C and the problem and/or question (s) show a two sided argument to be explored. |
| *Selection and explanation of the key population ecology concepts related to the scenario.* | 0-4 | 5-6 | 7-8 | 9-10 |
| | Concepts are not selected upfront but used in the presentation or concepts selected with no definitions at all. | Identification of one or two concepts that are relevant to explore for the question but not well defined or explained. | Multiple concepts identified and correctly defined or explained. Reasons for choice of concepts are given in relation to the question (s) and/or problem to be explored. | As in C and clearly links to some of the things we talked about in lectures and tutorials and/or practical investigations. |
| *Formulation of an argument throughout the presentation supported by facts and data.* | 0-9 | 10-11 | 12-15 | 16-20 |
| | The problem and/or question (s) is not explored. The student reproduces the lecture notes. There is no evidence to support claims and no examples are given. | Argument is maintained throughout the presentation. There is coverage and relevant evidence gathered but insufficient integration. | Balanced formulation of an argument. Conclusion is well reasoned and the entire presentation shows deeper understanding. Provides reflection for the entire task as part of conclusion | As in C and the student goes beyond 'expectations' and shows metacognitive thinking process to formulate the argument. |

## 10.14 APPENDIX N: PLANNED AND ADMINISTERED PRACTICAL ACTIVITIES

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# Division of Science and Technology Education

## LS III (EDUC 3108) POPULATION ECOLOGY PRE-LAB 1 – FOR 20 SEP 2017

There are different methods or techniques used to estimate the population size. Each technique is applicable to specific populations. The following table is designed to summarise these techniques. COPY and COMPLETE the table below in preparation for your practical investigation on Wednesday 20 September.

You will not be allowed to enter the lab without the pre-lab task.

| **Technique** | **Description** | **Advantages Where does this technique work best?** | **Disadvantages** | **Mathematical equations (if available)** |
|---|---|---|---|---|
| 1. Census | | | | |
| 2. Simple sampling | | | | |
| 3. Quadrat | | | | |
| 4. Mark-recapture | | | | |

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# Division of Science and Technology Education

## LS III (EDUC 3108) POPULATION ECOLOGY PRAC 1 – 20 SEP 2017

Overall Objectives

- Determining population size
- Compare the methods used to determine the population size

You need to submit a **word-processed (typed)** report on **Friday 22 September 2017 as you enter the labs for your tutorial session (09H00)**.

**PART A**

The aim of this investigation is to estimate the 'population' size using beads – estimating the number of beads in a bottle by simple sampling technique.

**You will need:**

- 500ml beaker
- Maize meal to fill the beaker
- Tiny beads
- A 5ml spoon
- Petri-dish/saucer

**What you should do:**

1. Mix the beads and maize meal thoroughly in the beaker using the spoon/spatula. (*1) Explain why you should not count the beads.* (1)
2. Use a 5ml spoon to remove one level spoon of the mixture from the bottle.
3. Spread the mixture in a petri-dish or saucer and count the number of beads
4. Estimate the total number of beads in the bottle using the following formula:

$$Estimate\ Total\ \#\ of\ beads = \#\ of\ beads\ in\ a\ sample \times \frac{habitat\ size}{sample\ size}$$

   NOTE: The habitat is your volume of beaker containing maize meal and beads and the sample size is the volume of the spoon

5. Put the mixture back in the beaker and mix again thoroughly. *(2) Why should you thoroughly mix again?* (1)
6. Repeat the exercise four more times *(3) Why is it necessary to repeat the exercise 4 more times?* (1)
7. Organise your results in a similar table to the one below: (4)

| **Sample number** | **# of beads in sample of spoon** | **Estimate total number of beads in the bottle** |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| **Average estimate number of beads in the beaker** | | |

**Questions:**

(4) How can you check whether your estimate was a good one or not? (2)

(5) Evaluate the investigation in terms of its strength and weaknesses and comment on the plan, design and technique used how you conducted the investigation and the obtained. (3)

(6) Would you do this investigation with your learners? Why? If your answer is No, which other investigation would you do with your learners and why? (3)

(7) A Wits zoologist worked out the number of worms that occurred in a certain habitat. The total area of that habitat was 2000 $m^2$. She chose five 10 $m^2$ plots and found 120, 100, 150, 130 and 100 worms in each plot respectively.

a. Estimate the total number of worms in that particular habitat. Show all your workings. (3)

b. Describe two ways in which the Zoologist could improve the reliability of these results. (2)

**PART B**

The aim of this investigation is to estimate the number of beads in a bottle using the mark-recapture technique. In this procedure, biologists capture animals and mark them in some way. The animals are returned unharmed to their environment. Once the animals have mixed with the original population, a second sample is taken the same way as the first. The number of marked individuals is counted as well as the number of individuals in the second sample.

**What you should do:**

- You will receive a bag that represents your population (beans or beads)
- With your eyes closed, capture a handful "animals" by removing them randomly from the bag.
- Place a mark on them using a marker
- Return the marked "animals" to the container. Record your data in the table by doing the necessary calculations for the last column.
- With your eyes closed, grab a handful of the population. This is the **recapture** step. Record the number of "animals" recaptured in total and the number that have a mark on them on the data table
- Return the "animals" to the bag and repeat. Do 6 recaptures.

Record your data using a table similar to this one: (4)

| **Trial number** | **Number marked in the sample** | **Estimate of total number in the bag** |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| **Average estimate to total number of beads/beans** | | |

(1) Count the actual size of your population. Did you overestimate or underestimate in your samples. Give possible reasons for that. (2)

(2) What assumptions must one work with when using this method? (2)

(3) Compare the two methods used in Part A and Part B. Comment on the accuracy and effectiveness of the two methods. (3)

**……...[30]……**

**LS III Population Ecology**

**Practical 2: Investigating population growth using the Avril Gulf Tuna Population Simulation**

**Accessed and adapted from:**
**http://physics.gmu.edu/~hgeller/HONORS227/sgi_ecology_ss_14_2.pdf**

***Background information***

"The Avril Gulf Tuna Population Simulation allows you to investigate what happens to the sustainability of a population of fish as various factors change. You will also determine how limiting factors affect population growth rates. With populations, a limiting factor is the factor that controls the growth of the population. For example, if a population of plants has plenty of sunlight, good soil, nutrients, and water but there is a herd of goats constantly grazing on the plants, the size of the population of plants is limited by the goats. The goats are the limiting factor in that scenario. Some factors are density-dependent factors - they vary according to how dense the population is. For example, a contagious disease is density-dependent because the number of organisms that become sick depends on how dense the population is and, therefore, how easily the disease is transmitted. Some factors are density-independent factors, such as seasons or severe weather, which affect organisms regardless of population density. There are four stages to the simulation. The first three stages explore different factors that affect population growth rates. The fourth stage combines all the factors of the previous three stages. As you work through the simulation, carefully follow the instructions provided at each stage"

Link: http://sepuplhs.org/high/sgi/teachers/fishery_sim.html

***What you need to do***

1. Work with your partner to follow the tutorial in the simulation to familiarize yourself with how the simulation works. Read each screen carefully and be sure you understand each part of the tutorial before moving to Stage 1 of the simulation.
2. In **Stage 1**, click on the "Show Normal Population Growth" box to see the graph of what happens to this population if reproduction, migration, and death rates are moderate.
3. Explore what happens to the population as you change the three variables and record your observations of what happens to the sustainability of the population. What variable settings cause the population growth rate to increase? What settings cause it to decrease? What settings cause the population growth rate to stay steady? What are the limiting factors?_____

4. Scientific advisors to the fishery have determined that the population is sustainable at 60,000 fish. Use the simulation to determine what settings for the three variables maintain the population at 60,000 fish.

5. Scientific advisors have re-examined the population data for the Avril Gulf tuna and determined that the population is sustainable at 80,000 fish. With your partner, predict what settings would maintain the population at 80,000 fish. Write down your predictions and then use the simulation to test your prediction. If necessary, change the settings as you run the simulation. Print the graph and record the settings in the space below.

6. Move to **Stage 2**, and repeat Steps 3 to 5. Note that in Stage 2 you cannot control pollution or disease events, which will occur at random intervals.
   (3)

   (4)

(5)

7. Move to **Stage 3**, and repeat Steps 3 to 5.
   (3)

   (4)

   (5)

8. Move to **Stage 4.** In this stage, all of the factors are combined. Predict what settings will allow for a maximum amount of fishing while maintaining the fish population (i.e., have a sustainable fishery). Repeat Steps 3 to 5, but incorporate the maximum amount of fishing possible.
   (3)

(4)

(5)

9. With your partner discuss the following questions. Record your conclusions in your science notebook.

   9.1 How does each of the factors in the simulation affect the sustainability of the fish population? Use the following table for your answers.

| Factor | How the factor affected the sustainability of the fish |
|---|---|
| | |
| | |
| | |
| | |
| | |

   9.2 Which factors are density-dependent and which are density-independent?

   9.3 How could a model, such as this simulation, help fisheries biologists make recommendations about setting fishing limits?

9.4 How can you use this simulation in your classroom? What would you need to consider before making a decision of using this simulation?

## 10.15 APPENDIX O: LIST OF FINAL CODES FOR THE ANALYSIS OF STUDENT INTERVIEW TRANSCRIPTS

| Codes | Description of the code |
|---|---|
| Student motivation | Describes students' motivation for and in learning the content |
| Gap in my teaching approach | Any description of a 'style' or method of teaching |
| Outcome of teaching approach | Description of the implications of the teaching approach |
| Content application and relevance | Description of the relevance of content taught for students |
| Messages portrayed | Description of what students gleaned from the teaching and the lecturer |
| Student gap in knowledge | Description of what students did not know |
| Link to other subjects | Any reference to other courses either comparing of drawing from what is done in other courses or subjects |
| Student desire | Describes what students would like to see and experience that they did not |
| Objectives of student desire | The implications of students' desires |
| Critique of teaching approaches | Describes the analysis and evaluation of the teaching styles and methods used by the lecturer |
| Student learning approach | Describes how the students learn |
| Linking of concepts | Describes if and when concepts where linked in lectures and the outcomes of that |
| Quality of test questions | Describes the kind and level of questions asked in the test |
| Alignment of level of content and test questioning | Students describing the link between the content taught, how it was taught and the questions in the test |
| Teaching approach | Reference to the methods and styles of teaching used by the lecturer |
| Instructional material | The materials like worksheets used in the lectures including other teaching and learning aids |
| Students' learning goal | Describes students reference to their goals for learning the content and using certain learning approaches |
| Students' learning approach | Describes how the students learn the content |
| Usage of learning management system | Describes how the learning management system was used (if at all) |
| Lecture pacing | Describes the rate of lecturer's teaching – if the lecturer was too fast or slow |
| Sequencing of concepts | Describes the sequencing of concepts and big ideas |
| Lecturer's conduct | Describes the kinds of interactions that the students had with the lecturer |
| Nature of tutorial questions | Describes how the tutorial questions are structured |
| Tutors | Describes the role that the tutors played in in the tutorial sessions including the tutors' conduct |
| Practical resources | Any reference to the materials used in the laboratories to carry out the practicals |
| Practical manual | Any reference to how the practical manual was structured including the contents of the manual |