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INVESTIGATING HOW TEACHER EDUCATORS CREATE OPPORTUNITIES FOR PRESERVICE TEACHERS TO LEARN BIOLOGY

By

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ABSTRACT

This study explored the opportunities created by four teacher educators in a teacher education programme to bring about meaningful learning. The study sought to understand the complex communicative approaches employed by teacher educators to provide preservice teachers with a platform for engagement with biology concepts in large lecture settings. A case study methodology was adopted for the study. The main purpose of this research was to find out how teacher educators can promote productive discussion and learning experiences in their lectures when teaching selected biology topics. Data sources involved observations of lessons taught by four biology teacher educators in 2017 and 2018 and individual interviews on teacher educators' teaching practices. To generate data for my study I observed four teacher educators teaching four different topics: population ecology, environmental studies, cell biology, and biochemistry of respiration. A total of fifteen lessons were observed and audio recorded. Data were analysed using the opportunities for the learning model. Results yielded eighteen categories of opportunities provided by teacher educators in their lectures. Findings suggest that teacher educators' lectures were interactive with a varying spread of elaborative prompts and probing that is supportive of preservice teachers' cognitive engagement with biology content. I discussed opportunities created by educators in their lecture spaces with a large student population and its implication for teacher education.

Keywords: Teacher education, Preservice teachers, Biology teaching, Opportunities to learn.

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.



Naomi Thomas

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Dedication

I dedicate this thesis to my late father, Mr Thomas Maisule Nyangani and my late brother

Sunday Thomas who taught me those “prayer changes things”.

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CHAPTER ONE: INTRODUCTION AND BACKGROUND OF THE STUDY

1.1 Introduction

This case study examines how teacher educators (are lecturers who teach preservice teachers in a teacher education context) create opportunities for learning life sciences concepts in a lecture environment. The goal is to learn how teacher educators (teacher educators prepare student teachers for learning both content and methods of teaching) can create strategic moments for interactions and thus opportunities to learn in large lecture halls, as well as how to engage a large group of students. When students learn science in a classroom setting, teacher talk and teacher-student interactions provide a primary source of information input, as language mediates the processes of mutual knowledge construction. Given the complexities of experiences that occur in science class during the teaching and learning phase, because of the critical role of verbal dialogue in students' meaning-making, it's crucial to understand how teacher educators prepare pre-service teachers (are student teachers undergoing training) for encounters of a classroom learning experience.

1.2 Background of the study

Recent global science education reforms have challenged traditional classroom practices and advocated involving students as active participants in the science classroom (European Commission, 2015; National research council, 2012). The call for the new reform of instructional practice was necessary because of the dominant stance of teacher-centred strategy which is prevalent in the undergraduate science classroom (Baniloweret al., 2018). The new reform advocates the exploration of science concepts in-depth thus the need to engage students in scientific content and practices (Krajick et al., 2014). To realise the new vision of science teaching and learning, educators will need to restructure their instructional practice where educators and students take up new roles (Windschitl & Stroupe, 2017; NRC, 2015). Hence, the need for students to be provided with opportunities to learn science as collaborators of knowledge in the meaning-making process in the classroom (NRC, 2015). Opportunities to learn are determined by the activities the teacher educators expose the students to in the social plane of the classroom (Greeno & Gresalfi, 2008). Tekkumru-Kisa et al. (2015) argued that to teacher educators afford students learning opportunities in their classroom experiences. Hence, the need to reflect on the practices that enable them to learn science while reasoning out claims which are relevant to a deeper understanding of the concept taught. Therefore, teacher educators need to plan their instructional content to feature cognitively demanding activities that will provide students spaces to learn both content and practices of the new reform for

science learning and hence teaching (Tekkumru-Kisa et al., 2015). The above explanation points to the differences in demands of instructional activity, thus when students are exposed to an activity each demands different cognitive engagement in the process (Tekkumru-Kisa et al. 2015) thus an opportunity to learn is not just exposure to the subject matter but also how student engage to refine their understanding (Hiebert & Grouws, 2007). Hence, my argument is that the activities students are exposed to in a lesson should reflect the picture of how students learn in science classrooms. Instructional activities are framed in interactional space between teacher educators and students. Teacher educators should deliberately create opportunities for engaging with the content of instruction as they interact with students through prompts, questions, and solicitations at strategic moments in the course of teaching. This interaction forms the basis of learning experiences in the classroom. Banilower et al. (2018) argued that educators play a significant role in the kind of opportunities they provide through their instructional practice. However, it is challenging to engage students with science content and also involve them with scientific practices in an interactional space, especially with a large population of students. Hence, the need for teacher educators to gradually share the burden of the discussion with the whole class as argued by (Soter et al., 2010). The nature of the interaction happening in the higher education learning space is what I will discuss in the next section.

1.2.1 Social interaction and teaching

Social interaction is relevant to the process of learning as it provides a platform through which the opportunity to learn science is created in the classroom (Cian & Cook, 2018; Wright & Schartner, 2013). Morton (2012) submits that classroom conversation is a relevant approach to enhance student participation as it provides opportunities for the teacher educators to engage with students' ideas as they negotiate the interactional space thus mediating the learning process. These conversations could be between student-student and student-teacher in a whole class argued by (Moore & Kearsley, 2011). This type of exchange is necessary for meaningful interaction in classrooms as it creates social space for teaching and hence learning to occur through sharing interactional moments (Li, 2011). Wagner (1994) posited that interaction encompasses the occurrences taking place in the learning environment with the student. However, Wagner did not explicitly describe what environment means. Hence, for my study, the environment embraces the teacher education classroom context, and the participants (preservice teachers and teacher educators) interact with the course materials in the process of teaching and learning. This conception of interaction embraces whole-class discussion, student-

student, and student-content interaction. The two categories of interaction indicate a social activity between individuals as discourse happens between two people and a whole-class situation in the interactional space. Similarly, listening to and/or watching the life or recorded video, interacting with a written or visual text, engaging with a PowerPoint presentation, or a combination of these activities all include student engagement with content. Students are more likely to learn details presented in these ways if they are prompted to engage with it in any way, which is why it is helpful to ask or invite them to do so by teacher educators to enhance the learning process. (Vygotsky, 1978) argued that interaction is a vital component of the education process as learning is essentially a socially mediated activity. The social constructivist theory is based on the belief that people actively build knowledge and understanding through social interaction in mind-engaging process to understanding of one's world (Vygotsky, 1978). In this study, students in a teacher education program must be active participants in the knowledge-building process to refine their understanding of concepts taught in the science classroom. Learning requires building on the prior information that the student brings to the situation and restructuring initial knowledge, according to constructivist views. Since learners have different skills, experiences, and interests in the background, they make different connections over time in building their knowledge. As stated by-Brooks and Brooks (1999):

> We construct our understandings of the world in which we live. We search for tools to help us understand our experiences. To do so is human nature... Each of us makes sense of our world by synthesizing new experiences into what we have previously come to understand. (p. 4)

Learning in the constructivist framework is seen as the integration of new concepts and skills with prior ideas built over time. Knowledge is thus the revision of old ideas that are refined over time. To transform the reality of learning in science classrooms deliberate portals of interaction must be created to allow students to engage with materials exposed to them in the social space. “This portal has the potential to change their experience in the classroom (Thomas & Poole 2018, p. 21)”. In this study, the term opportunity to learn (OTL) in the science classroom means the strategic moment, time, or turn that the teacher educator pause to open up space for a student to engage with the topic of discussion, argue, and make claims for what is being taught. These moments or strategic timings are deliberately created by the teacher educators to give students a chance to express their ideas about the topic of discussion as they interact as peers in the whole class or with the teacher educator one-on-one.

The significance of constructive classroom activities that contribute to effective learning is generally acknowledged, and the teacher's role in enhancing discursive experiences has been illustrated in a large body of previous literature (Cian & Cook, 2018; Msimanga & Lelliott, 2014; Mercer, Littleton, & Wegerif, 2009; Mortimer & Scott 2003). Teacher educators are the experts who ensure that their instruction, curricula, and assessments push students into increasingly difficult areas such as critical thinking, creativity, synthesis, and so on. Biggs (1999) is a notable proponent of the proposition that approaches to learning can be influenced and then learned by the teaching and learning circumstances. He also popularized the term constructive alignment, which refers to the agreement between what the instructor expects pupils to be able to do, know, or understand, how they teach, and what and how they assess.

When instructing pre-service teachers, teacher educators play a dual role. The dual function of the teacher educator entails considering pre-service teachers as students at a Higher Education Institution (HEI) as well as potential teachers (Russell, 1997). As a result, teaching pre-service teachers entails more than simply imparting instructional information 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.

However, the recent reforms in science education both in South Africa and globally calls for science teaching to be student-centred strategies (Department of Basic Education, 2017; Windschitl & Stroupe, 2017; NRC, 2015). Although extensive research has been conducted on the science classroom practices of teachers (Lehesvuori et al., 2018; Msimanga & Lelliott, 2012; Robertson et al., 2016; Windschitl & Stroupe, 2017) still little is known about how teacher educators create the opportunities to learn with a diverse population of students in a teacher education setting. Teacher training programmes provide one way for pre-service teachers to develop the skills and expertise in classroom practices and also provide rigorous opportunities for learning in science classrooms for all students (Windschitl & Stroupe, 2017; Windschitl et al., 2012). To achieve the vision of new science education reform Bybee (2014) and Windschitl and Stroupe (2017) argued that preservice teachers need to be prepared on how they can engage in learner-centred strategies as they transition to their future science classrooms.

1.2.3 Student engagement

Student engagement is a comprehensive and multifaceted phenomenon based on psychological, social, and/or cultural viewpoints with many meanings (Manu & Huaisheng, 2017; Zepke & Leach, 2010). This means that student engagement has varied meanings depending on individual views. To appraise the definitions, there are two components to the meaning of student engagement. One collection of meanings takes student participation as an anticipated consequence that represents the feelings, emotions, and actions of students. For example, Kahu (2013) describes student engagement to mean "individual state of mind" that includes students' emotions, cognition, and behaviour (p. 764). However, other meanings focus primarily on student behaviour, which shows that engagement is "the degree to which students engage in higher education activities that research shows its link with high-quality learning outcomes" (Krause & Coates, 2008a, p. 493). This implies that students' active participation in classroom activities that translate to refined understanding is referred to as student engagement. Also, Trowler and Trowler (2010) posited that student engagement is "the interaction of time, energy, and other relevant resources invested by students and the school to optimize student experience, improve student learning outcomes and development, and improve school performance and reputation" (p. 2). This definition is all-embracing; it takes into consideration the entire dynamics interplay, resources, and energy to enhance the process of learning and hence improve performance in school as a whole. Engagement is determined by the type of interaction that happens in a science classroom. Hence engagement is characterized as the degree to which the interaction involves students and the teacher educator in a social space (Azevedo & Sherin, 2012). This type of engagement occurs during classroom experiences but is impacted by the form and nature of instructional prompts, elaborations, and activities used by the lecturer and the quality of facilitation. Hence, student engagement involves participants' orchestration of activities which are necessary for learning and hence teaching (Walsh, 2006). These orchestration involves A cooperative learning session in the classroom involves students collaborating in small groups to complete a learning task. The teacher assigns the work with specific instructions. Students then collaborate on the activity with specific roles (for example, reporter, spokesperson, researcher, and recorder).

Collaborative learning, or the technique of dividing students into small groups to answer questions, collaborate on projects, and learn from one another, has emerged as one of the most powerful basic ideas in teaching. More emphasis is being placed on the educational value of conversation and dialogic discourse, for example, in the Common Core State Standards and associated instructional approaches. In this study teacher educators employed all resources in the science classroom to facilitate students' engagement with the science content they

encounter in the course of meaning negotiation (NRC,2015) this is because of the limitation of whole class discussion. Learning activities is addressed in the next section.

1.2.4 Learning activities

Greeno and Gresalfi (2008) define the opportunity to learn (OTL) as the affordances of a setting for changing participation and practice. They stated, "One of the most critical aspects of understanding (OTL) comes from the activity system in which students are participating. Classroom activities are generally structured as tasks, so OTL depends on the tasks that students have to work on" (Greeno & Gresalfi, 2008, p. 177). As a result, instructional activities are an integral part of an activity structure that can affect students' learning opportunities in science classes. They form students' opportunities to learn science by communicating with the other components of the activity system in the context. Historically, scholars have called for a detailed review of tasks (Hiebert & Wearne, 2022; Stein et al. 1996; Tekkumru-Kisa et al., 2015; Doyle 1983;) since tasks are regarded as "the most significant connection between teachers, curriculum, and student outcomes" (Blumenfeld, 1992, p. 81). It was argued that what and how students learn is largely defined by the tasks that they are assigned (Doyle, 1983; Hiebert & Wearne, 2022). A science task (as part of a lesson or spanning multiple lessons) can be a project, a science activity, a lab, a set of problems, or a question that students are given to focus their attention on particular scientific ideas and/or practices. The deep thinking that is required for students to successfully engage in an instructional task is referred to as Cognitive demand (Doyle 1983; Tekkumru-Kisa et al., 2015; Stein et al., 1996). The cognitive demands of tasks, and thus the forms of agency afforded to students in classrooms, make a difference in their ability to learn (Greeno & Gresalfi, 2008). Science tasks that engage the mind are often less structured, more complex, and time-consuming than routine and procedural tasks.

1.2.5 Teaching in higher education

Recently student-centred strategies have emerged as powerful tools for reforming science education. Researchers have advocated for key features of these approaches. Students are at the core of both models, and both emphasize student engagement. Based on responsibility for learning shifts, the following results were obtained from students, the teacher's role also changes from that of final-form authority dispensing information to that of a guide who encourages the learning process and promotes the development of a student's learning skills (Soter et al., 2010). Often, the best teachers hide their efforts. The success of a student is measured by what he or she learns, not by what the teacher teaches. Furthermore, as student-centred strategies are more oriented toward student perspectives and motivations, they tend to concentrate on specific, concrete occasions wherein target knowledge can be applied. In

addition to increasing motivation and meaning (which many educators consider to be essential to effective learning), contextualizing the learning enhances student engagement. Rather than merely providing supplementary illustrations or peripheral sidebars, cases and problems have a central role in learning. Based on the views of cognitivism, this style of learning reflects the idea that our brains learn best by analogy and models as well as through the interpretation and application of abstract general principles. In addition to facilitating thinking skills development and fostering an analytic understanding of science, student-centred strategies also have the potential to achieve substantial academic changes. Students typically exercise, analyse, interpret, and think creatively as they work on cases or problems. The benefit of practising must also be complemented by a reflection on experience that will enrich students' understanding of scientific practices). However, these lessons don't appear by themselves. To accomplish this goal, instructors must make deliberate choices and design activities thoughtfully. To prepare our pre-service teachers for meaningful engagement with science concepts exposure to the diverse and ever-changing lecture purpose of their education has to be specific to the contexts (Morton et al., 2012). One of the basic roles of teacher educators is planning their instructional delivery. The planning is done following the institutional demand. Teacher educators are expected to have a good understanding of the values of the institution in which they operate. This is relevant because it has a great influence on the curriculum. The conceptions of the curriculum by educators influence how they plan the learning experiences of their students' Teacher educators' knowledge and understanding of student learning gleaned from the literature suggest that the attention given to curriculum plan and development, the preparation of learning experiences and evaluation of student learning all have a significant impact on students' approaches to learning. Vygotsky (1978) is known for emphasizing the role of social and cultural context and process in development and learning. His theories on students' ''Zones of Proximal Development,'' or the gap between what they can understand on their own and what they can understand with help, with sufficient support, a learner can be brought faster up a learning curve, and their ZPD can be continuously advanced. This idea is at the heart of concepts like "scaffolding" learning, which entails providing assistance and support. In higher education, balanced decisions about tapering support are often necessary to prevent spoon-feeding and encourage the ability to think independently (Brooks & Brooks, 1999, p. 16). Lave and Wenger (1991), work for example is related to a social theory of learning known as situated learning. Situated learning places emphasis on the learner (or worker) as he/she works with others to develop/create mutual understanding as part of a community of practice, and it focuses on understanding

knowledge and learning in context. As a result, their outlook on learning is relational, and it downplays the value of continuous schema reformation and transformation through a single effort or within individuals, or of learning particular types of things through books or out of context. Situated learning considers learning to be a collaborative activity in which new information can be created (Lave & Wenger, 1991). 'It is important to remember that what the student does is more important in determining what is learned than what the teacher does' (Biggs, 1993). This statement is consistent with a constructivist view and also reminds us that students in higher education must engage with and take considerable responsibility for their learning. Students must coordinate knowledge and be able to apply it Karatas, 2017). If learning is to occur, the teacher educators cannot do all of the labour; instead, the teacher educators must ensure that course design, teaching and learning opportunities, and evaluation are geared toward supporting students to learn. Learning necessitates opportunities for practice and exploration, as well as time and space to think or reflect 'in your head' and interact with others, as well as learning from and with peers and experts (Lave & Wenger, 1991). These imperatives, coupled with those of the discipline, should affect how teacher educators present content in their lectures in a higher education context. Studies on classroom discussion are becoming more common as a way to inform and examine the science teaching and learning process. The explanation for this is a philosophical belief that language and thought are inextricably related. Humans learn through the mediation of signals, according to the socio-cultural approach (Vygotsky, 1978). Thus, language is a collection of signs that enables us to communicate our experiences of the world with others, and this is done by shared involvement in specific social activities (Bakhtin, 1986a; Vosniadou et al., 2008). As a consequence, language is more than just a way of interacting with others; it is also a means of forming and expressing a common view of the world, a powerful system that enables us to think together. Aside from that, learning science involves learning scientific languages, which classify a particular worldview relevant to science's social activities in society (Lemke, 1990). As a result, science education researchers are interested in contributing to the knowledge base of discursive interactions, which helps teachers and students to pursue a shared understanding based on scientific principles. This study aims to understand the changing aspects of teacher educators' students' interactions in the life sciences classroom, and to explore the possibilities for learning, over time, in teacher educators' approaches to handling these instant interactions. Byers et al. (2020) suggested that science teaching and therefore learning has shifted greatly from a transmission mode of teaching to an active learner-centered approach where students' ideas are encouraged through the joint meaning-

making of their experiences. Meaningful conversation, in which different ideas are considered, promotes conceptual understanding in science and is in line with South Africa's teacher education curriculum. Creating learning opportunities is critical to preservice teacher education space hence I argue that classroom discussion can be employed as a pedagogical tool of great importance by teacher educators in the process of meaning negotiation in their lectures. This will be a platform for a cognitively engaging learning experience for their preservice teachers.

Teacher educators must be both professional and subject area experts in order to instruct preservice teachers. This is because teacher educators must prepare preservice teachers to comprehend both teaching and the subject matter. This is because teacher educators must prepare preservice teachers to comprehend both teaching and the subject matter. This dual position places a premium on the professional competence of teacher educators. Teacher educators must provide opportunities for preservice teachers to learn and experience teaching as students. Expert teachers of teaching, according to Burn and Mutton (2013), should be active in teaching practice. This means that professional teacher educators should expose their preservice teachers to teaching information separate from the subject matter expertise required to teach course topic.

This includes assisting pre-service teachers in gaining teaching experience, whether they are enrolled in a topic or technique course. According to Loughran (2006), a teacher educator must assist pre-service teachers in obtaining information relevant to these two learning demands (learning about teaching and subject matter) because these two learning demands distinguish pre-service students from other students.

Agendas for pre-service teachers' learning Loughran (2006) defines learning objectives as "the key aspects that students of teaching should learn." Loughran (2006) offers three pre-service teacher learning agendas that teacher educators must consider. Students should first learn about the specific material being taught. Second, students should learn how to learn. Third, they should learn how to teach. The first agenda focuses on pre-service teachers' comprehension of what is taught. This can be professional knowledge about what it means to be a teacher or subject matter knowledge about a specific teaching subject, such as science. This indicates that in order for a teacher educator to fulfill this objective, they must have a solid comprehension of the subject matter knowledge provided to the students. This means that a teacher educator

must have a solid comprehension of the subject matter information provided to preservice teachers in order to fulfill this objective. This study is important to the South African context because the findings have the potential to enlighten stakeholders about teaching strategies that emphasise the relevance of talk of students and may enhance the meaningful learning of life sciences with Specific reference to science talk as a strategy for pre-service teachers learning in science education.

1.3 Rationale

My interest in this research came from my experience as a tutor in the teacher education programme. I had completed compulsory teaching as a graduate assistant in my country and was considered a successful teacher based on my students' evaluation of my teaching. However, working closely with teacher educators and observing the complex interactions in their lectures, I knew if I will survive in a higher education setting I need to learn how to improve my communication skills to reach out to a large population of students. Thus my interest in social interaction and the role of conversation in creating opportunities for learning in science classrooms. In recent years, there has been a lot of conversation about productive discussion and teacher educators' role in engaging students' ideas to support them in meaning-making interactions in the science classroom (Robertson et al., 2016). Over the last few decades, there has been a lot of debate and concern about the constraints imposed by students' learning science as a fragmented set of ideas presented through "a mile wide and an inch deep" curricula (Schmidt et al., 1997). The aim is to move science teaching away from a focus on many discrete facts covered at a superficial level to a focus on a smaller number of disciplinary core ideas that can be explored in-depth (Krajcik et al., 2014). To achieve this aim, students will need to participate in scientific activities to explain phenomena and gain understanding through scientific practices. Without a question, achieving this vision would necessitate major improvements in the way science is taught and learned in many classrooms (NRC, 2015). This means the learning of science curricula needs to be presented to students taking into consideration both the content and practices of the discipline by educators. Hence the selection and design of learning activities are key to the type of opportunities provided to the student to learn science concepts in the science classroom. In response to these issues, the new science education reform (NRC, 2012) calls for new instructional strategies that will improve science teaching and learning. Instructional activities have the potential of engaging students in high levels of thinking; however, these activities have to be cognitively demanding (Tekkumru-Kisa et al., 2015). Hence for students

to participate and engage actively in the learning process teacher educators needs to select activities that engage the mind of students in high-level reasoning (Jackson et al., 2022; Kang et al., 2016; Stein et al., 1996). This is because productive opportunities for learning science are triggered by cognitively demanding activities in classroom teaching-learning encounters.

There has been a lot of research done in schools about the importance of communication in science classes (Mitchell, 2010). However, little research is conducted in higher education classes, especially in teacher education (Geelan, 2012; Lehesvuori et al., 2013; Peters, 2010). This study is crucial to the South African context because the findings have the potential to add current knowledge of diverse opportunities inherent in teacher education to facilitate meaningful learning of preservice teachers. It will also identify features of contingent interactions within a large diverse student population that enhance the quality of science concepts communication.

1.4 Significance of the study

The importance of such an inquiry resides in the potential to add current knowledge on classroom conversation and inform science teacher education and preservice teacher preparation. Besides, the findings will be useful to inform science educators about the ongoing debates in classroom practice. The present study will also be useful to suggest ideas on how to explore opportunities to learn in lecture settings are harnessed. Although the results of a case study are not generalisable, the findings of this study can shed light on other challenging areas facilitating meaningful talk practices as a tool to help in teacher education not only in South Africa but in the rest of Africa. Lastly; this study may shed more insights into the role of teacher educators as facilitators of learning opportunities in the contingent elaboration of preservice teachers' interaction in their lecture spaces.

1.5 Purpose of Study

The main goal of this research is to understand how teacher educators can promote productive discussion and learning experiences in their science lectures. The reviewed literature emphasizes the importance of life science teachers as agents of novel teaching methods that stimulate students' prior knowledge. This experience serves as a foundation for developing a new understanding of scientific concepts (Tunnicliffe, 2006; Tunnicliffe & Ueckert, 2007). This is in line with Ausubel's (2012) theory that meaningful learning can only occur when new information is related to prior knowledge. According to the current conceptual change theory, learners must reorganize their schemata to fit new information to gain a new scientific understanding. Furthermore, it agrees with Shulman's (1987) claim that students' growth in

language teaching, such as biology, in the classroom is dependent on the teacher's combination of contextual and pedagogical skills (Dawson & Venville, 2010). Additionally, Osborne (2010) suggests that teacher training should be a continuous development of preservice teachers' skills in science teaching.

1.6 Aims and Objectives of the study

This study aimed to explore how teacher educators facilitate interactions in their lectures through the use of a communicative approach as a teaching strategy and provide preservice teachers opportunities to engage with life science concepts. In pursuit of these aims, the following objectives were therefore formulated:

Exploring the teaching strategies used by biology teacher educators in their lectures to facilitate opportunities to learn

Evaluating lecturers' views regarding pre-service teacher preparations within life science lectures and how their practice mediates learning.

Exploring major challenges to implementing interactional strategies to provide learning opportunities.

Investigating the opportunities provided by science discussion to refine the understanding of preservice teachers.

1.7 Research questions

How do biology teacher educators facilitate the creation of opportunities to learn science concepts from selected biology topics in their lectures?

1. How do biology teacher educators facilitate the creation of opportunities to learn science concepts from selected biology topics in teacher education setting?
2. What is the nature of pre-service teachers' engagement with opportunities provided by educators?
3. What evidence of pre-service teacher learning can be gleaned from their engagement with learning opportunities in teacher education setting?

My study might provide illumination into pedagogical strategies used by biology teacher educators in their lectures and how opportunities are created for preservice teachers' to actively participate with science content despite the large lecture spaces. The study might

reveal some of the difficulties of a shift in negotiating between the language of science and everyday knowledge preservice teachers come to class with as my data site consists of students with diverse home language backgrounds.

1.8 The context of my study

Globally, there are two major institutional models for preservice teacher education programmes: concurrent and consecutive models (Zuzovsky, & Donitsa-Schmidt, 2017; Nyamupangedengu, 2016). The concurrent model incorporates and teaches both disciplinary and pedagogical knowledge at the same time (Musset, 2010). The Wits University School of Education (WSoE) is my data site that uses the concurrent model where pre-service teachers are taught both the disciplinary and pedagogical components by the teacher educators in the same School of Education (Nyamupangedengu, 2016). The concurrent model used at (WSoE) is one in which pre-service teachers are taught both the disciplinary and practice components by the same teacher educators in the same School of Education. The Wits School of Education (WSoE) teacher education programme is organised into what are called streams around which courses are built (Nyamupangedengu, 2016). Pre-service teachers in the Bachelor of Education (B.Ed.) science program take a particular level subject course and its methodology at the same time. For example, a third-year biology major pre-service teacher will take the Biology III content course and its methodology. At (WSoE), the academic year is split into two semesters. Each semester consists of 12 weeks of classroom instruction and four weeks of exams. A one-week mid-semester break splits the 12 weeks of teaching and learning into six-week blocks or terms.

1.9 The Researcher and Positionality

Tobin (2009) and Henning and van Rensburg (2004) reasoned that qualitative scholars whose paradigm of study is interpretive in nature must provide a clear explanation of who they are. Positionality is the definition of the station in any situation as distinct by race, gender, class, and other important social positions (Maher & Tetreault, 1994, p. 22). Peshkin (2001) posited that since it is difficult to achieve detachment in social sciences research, I need to acknowledge and explicitly identify my subjectivities. In this way, I can bring to my research awareness of the subjective lenses through which we view our data and communicate our perspectives to our audience. A sociocultural perspective on learning (Lantolf & Thorne, 2006; Vygotsky, 1978) was the key element of my study, as it fitted well with my experiences and observations over the years. Working with pre-service teachers daily, and in such proximity, allowed me to examine how conversation scaffolds or did not scaffold their

learning. Thus here is my background and brief experience that informs my subjectivity in the study. Ungvarsky (2019) posited that the influence of researcher bias can be minimised by disclosing the possible influence and effect our biases and experience can have on our study.

Hence, I disclose this in the next paragraph. I am a black female student, before enrolling as a student I was living in Jalingo the north-east of Nigeria. I was born in Jalingo a rural district of the former Muri emirate in Adamawa province of Gongola state. I started my elementary education in Jalingo and then later moved to Kaduna state to stay with my father who was a military officer in the Nigerian army. Thus, there was a shift in my education from a public school to a military school with strict training for learners and competition for me coming from a public school hence there was a struggle for me how to fit into this new school community. I progressed in the community until grade eight when my father had to live in Kaduna for retirement due to an injury he sustained from the Biafran war. I was transferred to another community school where I completed my schooling. I passed and later enrolled in a science secondary school and graduated with an average pass in the sciences. This qualified me for a college of education where I enrolled as a science teacher in both Chemistry and biology. I received training and qualified with the basic teaching qualification for my country Nigeria. After graduation, I took a teaching job as a basic science teacher for a short period. From there I immediately enrolled in Ahmadu Bello University and graduated as a full-fledged science teacher of biology. There was an opportunity for a science teacher so I applied and moved to a college of education where I taught courses in global ecology. I served in the college for some time then later moved to a state-owned university managed by public resources. I lived in Jalingo teaching and later applied for a master's programme in education at the University of Jos. I started my teaching career in an environment with learners from diverse ethnic communities with different home languages. I had to pitch myself in this challenging community of learners who had to negotiate the boundaries of different language borders to learn science and the language of teaching I was a teacher educator in a young growing University before coming to Witwatersrand University in Johannesburg for my doctoral study. To be effective in the university setting I needed to improve my qualification hence I enrolled for a Ph.D. qualification to help my promotion and have a voice in my teaching community because without this relevant qualification, I would be limited in the community.

I realised the influence of teacher educators on the learning of their students is critical to gaining a meaningful understanding of life sciences concepts and also their transition to their future roles as educators. Hence, I concur with (Vygotsky, 1978) about the perspective of how humans learn through the mediation of signals and language is a collection of signs that enables us to communicate our experiences of the world with others, and this is done through shared involvement in specific social activities (Bakhtin, 1986a) and elaboration to improve the quality of learning (Wood & Wood, 2012). The type of approaches used by teacher educators will determine the opportunities they give their students to learn science hence my interest in the topic in my study. I agree with (Mortimer & Scott, 2003) that interactive conversation can provide a platform for preservice teacher to externalize their prior knowledge and refine the new understanding in the science classroom. I have always been interested in nature and how people engage in conversations within their cultural settings. My people the Wurkun ethnic group called conversation a ‘’pool of voices’’ like the sound of river flow. Although I was a quiet timid child in my early years of schooling, when I joined a college to train as a teacher I had to start learning how to engage in conversations with my peers both in class and outside the classroom (informal) setting. With my education grounding in science teaching my views were strongly influenced by constructivists, believing in working with students' prior knowledge and mediating their learning. My thinking is that science happens in the everyday world out there and it can be explored through the medium of communication and interaction in a cultural setting so I regard myself as a realist.

1.10 Overview of the design

In this study, I employed a qualitative case study design to gain an understanding of the phenomenon. To be precise, I used an exploratory case study in which I adopted a multiple case study design since the study involved an in-depth description of the processes of conversation and interaction in the science classroom of teacher education. I purposively selected all year three life science preservice teachers and four of their teacher educators who consented to participate because they can provide an informed understanding of the phenomenon to be researched (Creswell, 2014). This selection allows the researcher maximum use of a small sample for data generation (Flyvbjerg, 2006). All participants were informed and gave consent knowing that their participation in the study was voluntary and other students not willing were released from the study with no fear of any consequences from the researcher. Pseudonyms were used in all writing or presentation in which the data

is used. I assured the participants that the responses will be kept confidential and that confidentiality will be maintained throughout the study. All data was generated in one university so the context is the same for all the teacher educators selected. Data sources for the study included: audio recordings of classroom observations of lectures and interviews.

1.11 Assumptions

1.11.1 Assumptions

According to the study, learners learn through active mediation between a more knowledgeable person and themselves, as well as by interacting with content. Learning is a collaborative process that occurs both within the context of the community of practice that the learner aspires to belong to (in this case, the teaching of science community) until learners become fully-fledged participants within the community and not just peripheral participants. This particular assumption is informed by work on Sociocultural learning theory (Vygotsky, 1978), cognitive apprenticeship (Lave & Wenger, 1991), and the conceptual framework of the study. Through this understanding of learning as mediated by teaching for the students (Scott et al, 2006; Vygotsky, 1978), the students will eventually internalise the content they encounter in the social plane. Given the nature of the study, this epistemological position was chosen. The study aimed to understand how the mediating activity of four teacher educators evolved and was enacted within a situated setting (in this case a teacher education programme).

1.11.2 Operational definition of terms

The following terms are used in this study and are clearly described for this study in the ways outlined below:

Elaboration:	Extended questioning prompts by educators' to preservice teachers ' contribution in the science classroom.
Breakdown:	Unsuitable contribution given by preservice teachers in the course a life sciences lecture.
Sophistication:	A suitable response by preservice teachers but elaborate details is required to establish understanding of the topic of discussion.
Individuation:	This is teacher educators questioning response to a whole class chorus response to a solicitation.

Collectivisation: Teacher educators' questioning response to student's correct life sciences contribution for shared whole-class understanding.

Opportunities: These are moments or strategic timings that are deliberately created by the teacher educator to give students a chance to express their ideas about the topic of discussion as they interact as peers in the whole class or with the teacher educator one on one.

A science activity: Is a set of problems, or a question that students are given to focus their attention on particular scientific ideas and/or practices.

1.11 .3 Overview of the study

In the introduction chapter, I articulate the problem-purpose statement for my study and the study rationale. Chapter 2 presents the literature review and theoretical framework. Chapter 3 outlines the research methodology and my research questions and explains the research methodology. Chapter 4 Chapter four- data analysis and presentation of results: Therefore, I will start by presenting the results from the observations about the role of opportunities in a meaningful understanding of science content. Then, I present results on classroom conversation and how the teacher educators used certain communicative approaches in their lectures. Lastly, I do an in-depth analysis, interpretation, and discussion of teacher conversation and interaction and how the exchange provides learning opportunities in teaching sequences. Chapter 5 I gave details of opportunities created by two educators in their biology lectures. Chapter 6 I gave the details of interactions and opportunities provided by two educators as the open up spaces of participation and engagement with life sciences concepts in the science classrooms. Chapter 7 Conclusion, in this chapter I discuss the summary of findings, insights and conclusion. Recommendations for research are provided.

1.12 Chapter Summary

In this chapter, I presented a general introduction to the thesis with a detailed background of the study. The background explicitly discussed the need to use conversation as a tool to provide opportunities for learning in the teacher education programme. I also provided my background as a teacher educator in a different African context (Nigeria) and how it will affect what I might perceive in the study. Finally, I gave the thesis overview. In the next chapter, I present a review of relevant literature for the thesis.

CHAPTER TWO: LITERATURE REVIEW AND THE THEORETICAL FRAMEWORK

2.1 Introduction

To review the literature relevant to the study, I first described what is meant by an opportunity to learn in a biology teacher education classroom. I then engaged briefly with the theories of how humans learn and finally presented the conceptual framework for the study. Thus, the review has been divided into sub-sections.

2.2 Opportunities to learn

Greeno and Gresalfi (2008) defined opportunities to learn as "affordances for changing participation and practice. In this view, understanding a learner's trajectory involves hypotheses about affordances that are available to the learner to participate in particular ways" (p. 172).

These definitions suggest that there are experiences in the classroom that needs to be evolving to ensure opportunities are made visible for learning to happen. The changing culture of science in the classroom hence, allows for the sharing of responsibilities in the process of teaching and learning.

McGregor and Frodsham (2019) argued that when students are allowed to interact with scientific content in the classroom in an encounter that engages thinking, that kind of interaction is referred to as a learning opportunity. Alozie and Mitchell (2014) contended that the assistance accorded to students to verbalise their ideas and hence refine them over time is referred to as learning opportunities. This assistance usually is in form of solicitations by teacher educators in the cause of teaching for preservice teachers to respond to the topic of discussion. The solicitation for interaction is key to the learning process.

Tekkumru-Kisa et al. (2015) argued that providing occasions for students to participate in instructional activities (such as asking questions, arguing from facts, and modelling) as they describe phenomena or solve problems has become more relevant in science classrooms. These occasions they term as opportunities to learn. The exposure to instructional activities is supported by teacher educators creating deliberate openings for preservice teachers to engage with the topic or science content in the course of lecture enactment in their biology classroom. However, Banilower et al. (2018) argued that for the strategic occasion of encounters with instructional activities to become learning opportunities the activities must deeply be mind-engaging for preservice teachers. Teacher educators create opportunities for learning as preservice teachers are involved with analysing examples of teaching, such as video recordings of lessons or written student work, as part of this practice-focused approach (Herbst & Chazan,

2011a; Santagata & Yeh, 2014). Involving preservice teachers in this classroom experience provides them with the requisite interactive encounter with practices of teaching. This is relevant in their learning process of becoming teacher educators in the future. In this study, the term opportunity to learn for preservice teachers is defined as the deliberate occasions provided by biology teacher educators for learning to happen as preservice teachers engage with science concepts in science classrooms in an interactive process. Hence, my argument is that to prepare preservice teachers there is a need to engage them in deliberate instructional activities that embrace both teaching practices and science communicative strategies.

2.3 Constructivism

"Constructivism is a learning theory that contends that people consciously construct their own knowledge, and that truth is influenced by the learner's experiences'' (Elliott et al., 2000, p. 256). Constructivism, according to Arends (1998), believes in the learner's creation of meaning through experience, and that meaning is informed by the interaction of prior awareness and new events. Cognitivist teaching approaches seek to help students assimilate new information into their current knowledge while also allowing them to adapt their existing cognitive structure to accommodate the information. The basic principle of constructivism is that human learning is constructed and that learners create new knowledge due to their previous knowledge. This prior knowledge has an impact on the new or changed knowledge that a person can create as a result of new learning experiences (Phillips, 1995).

The second concept is that learning is a process that is active rather than passive. The passive view of teaching views the learner as 'an empty vessel' to be filled with knowledge, while constructivism notes that learners construct meaning only by active interaction with the environment (such as experiments or real-world problem solving, (Mortimer & Scott, 2003).

The notion of conceptual understanding is a process of meaning negotiation and making connections with previous knowledge in contrast to the passive reception of new ideas by students (Mortimer & Scott, 2003; Piaget, 2003). Vygotsky (1978) claims that cognitive growth originates from being supported by a more knowledgeable peer within the zone of proximal development, where children and their partners co-construct information. Hence, the classroom experience of teaching and learning is the process of knowledge negotiation. There are numerous constructivist viewpoints, including cognitive, social, and radical constructivist approaches. The fundamental characteristic of constructivism that students' prior experience is a prerequisite for learning new concepts is shared by these constructivist paradigms. Cognitive

constructivism, based on Piaget's (2003) work, and radical constructivism by Von Glasersfeld (1974) are all examples of constructivism. In contrast to conventional education, where information is essentially passively conveyed by teachers to students, constructivist learning theory underpins several student-centred teaching approaches and techniques (Oliver, 2000).

Constructivists formulated a cognitive approach that prioritised mental processes over observable actions. The concept that information is made up of abstract mental representations like propositions and images, as well as a system that operates on those representations, is shared by most cognitivist approaches. Learners are seen as consciously building information based on their previous experiences (Powell & Kalina, 2009). The theory emphasising mental functions rather than visible behaviour. Their ideas view knowledge as mental representations and images. Learners are seen as consciously constructing knowledge based on their pre-existing cognitive constructs. As a result, learning is dependent on the learner's cognitive development level, and recognizing the learner's current conceptual context is critical to comprehending the learning process. Information is made up of active mental representations resulting from previous learning experiences (Piaget, 1968). Each learner interprets their experiences and information in light of their prior knowledge, cognitive stage, cultural context, personal history, and other factors. These factors help learners organize their experiences and pick and transform new information. Next, I discuss the sociocultural theory adopted for this study.

2.2.1 Social constructivist theory

The social constructivist theory posits that learning is a social process that is supported by the collective interaction of a cultural setting. In other words, the process of learning cannot divorce the aspect of teaching hence the teacher educator plays a vital role in directing the classroom experience. However, Vygotsky (1978) argued that learners should not be passive recipients of knowledge but active negotiators of shared understanding. Vygotsky (1978) posited that being in agreement with a social community and acquiring tools of that social setting is a feature of human experience:

> The internalization of cultural forms of behaviour involves the reconstruction of psychological activity based on sign operations. Psychological processes as they appear in animals cease to exist; they are incorporated into this system of behaviour and are culturally reconstituted and developed to form a new psychological entity. The internalization of socially rooted and historically developed activities is the distinguishing feature of human psychology. (p. 57)

This means learning scientific language and gaining new understanding is supported by the social constructivist model, hence the teacher educator provides opportunities to engage in discussions in the classroom community and this is a significant human endeavour. The process of internalization of cultural forms of behaviour and reconstruction of knowledge as a human endeavour is discussed in the section below.

Vygotsky (1978), documents that in the inter-psychological plane, learning is first mediated. Learning is mediated in this setting as learners interact with other individuals socially and culturally. Concerning a classroom situation, this is when learners consciously participate in discussions describing, debating, criticizing constructively, and exploring the opinions of each other. It is then mediated in the intra-psychological plane after learning has been mediated in the inter-psychological plane. Vygotsky outlines in this field that learners internalise social interactions, engaging with their peers or instructors, causing their thought to be influenced. Internalisation is a method of converting a social exercise into a psychological activity, according to (Wertsch, 1985). The intra-psychological degree exists in the student's mind.

The inter-psychological plane is important as it is the plane from which the knowledge that students internalise originates. Studies have shown that students do not always have accurate conceptions of science, which means that during student-student interaction, one peer's misconceptions may be transferred to the other peer. Thus, it is important to carefully track this form of interaction. In other words, to avoid the perpetuation of stereotypes and to allow conceptual improvement or learning, the knowledge exchanged on the inter-psychological plane needs to be carefully monitored.

Vygotsky (1978) notes that individual students have completely formed mental functions and less developed mental functions. Fully developed mental functions reflect the actual development level of students and are measured by the capacity of learners to perform tasks without assistance. Mental functions that are yet to develop suggest the future level of development of students and are detected. The actual level of development of individual learners can be changed within the proximal development zone (ZPD). “ZPD is the difference between the actual level of development as determined by independent problem-solving and the level of potential development as determined by problem-solving with more capable peers under adult guidance” (Vygotsky 1978, p. 86).

According to ZPD, a person with more knowledge or skill can effectively promote a learner's growth by guiding them through tasks that are just beyond their current ability. As the learner

builds skill and confidence, the expert gradually withdraws guidance until the student can accomplish the activity independently. Vygotsky felt that if a learner is in the zone of proximal development for a specific task, providing sufficient support will provide the student with enough of a "boost" to complete the task.

Educators are recommended to focus on three crucial components that facilitate the learning process in order to help a person advance through the zone of proximal development:

Someone with more knowledge and abilities than the learner (a more knowledgeable other).

Interactions with a skilled instructor that allow the student to observe and practice their abilities.

Scaffolding, or supportive activities offered by the educator or a more competent peer to help the learner navigate the ZPD.

In the literature, the ZPD has become synonymous with the term scaffolding. It should be noted, however, that Vygotsky never used this term in his writings, and it was coined by Wood, Bruner, and Ross (1976).

Scaffolding refers to the activities offered by the educator or a more competent peer to help the learner go through the zone of proximal development. Much like a scaffold is removed from a building during construction, support is tapered down (i.e. withdrawn) as it becomes superfluous. The student will thereafter be able to complete the work on his or her own.

Wood et al. (1976, p. 90) define scaffolding as a process "that allows a child or novice to solve a task or achieve a goal that would otherwise be impossible." Scaffolds, they note, require the adult to "control those elements of the task that are initially beyond the learner's capability, allowing him to concentrate on and complete only those elements that are within his range of competence" (p. 90).

It is vital to highlight that in the literature, the phrases cooperative learning, scaffolding, and guided learning all have the same meaning.

Anyone who has a greater understanding or a higher ability level in a given task, procedure, or concept than the learner is referred to as the more knowledgeable other (MKO).

It is critical to remember that the MKO is not always an adult or a teacher. It could be a peer, a younger person, or even technology or media, as long as it provides the learner with relevant information.

ZPD is central to teaching and learning. Earlier research considered the more knowledgeable one to be an adult, researcher, or teacher, according to (Ohta, 2001). However, during the student-student conversation, a student can assist a less knowledgeable peer, allowing the less knowledgeable peer to engage in knowledge building, thus shifting their actual level of development (Ohta, 2001).

It means that during student-student learning interactions, depending on the actual development level of the student concerning the concepts under study, the role of the student can shift from being the less knowledgeable peer to a more knowledgeable peer and vice versa. This, therefore, signifies the valuable role that student interactions can play in enabling learning. Vygotsky's sociocultural view of learning, then advocates that to engage in higher mental reasoning an individual must relate socially with the language of the discipline and this happens through the medium of an interactional tool in the social plane of lecture setting being my data site (Vygotsky, 1978). Both science and prior knowledge are appropriated through social interaction. Discussion is used to voice the process of internalising (Vygotsky, 1978) what students are exposed to for the first time in lectures are called "conceptual tools". As such, talk is a tool to voice out what a student is thinking in his or her mind. Language provides the medium of this expression in the science classroom (lecture setting) and is later applied for personal use. Thus, the social language of science and the scientific ways of talking and thinking is developed in a community; this community is the lecture setting in this study. The understanding of what knowledge students are exposed to is significant in facilitating learning. Novak (2010) and Ausubel (2012) posited that learning in a meaningful way is only possible if new information is relevant to previous understanding. Similarly, Carey contends that recognizing conceptual discontinuities in which new representational systems emerge with more expressive power than core cognition but are also incommensurate with core cognition and other earlier representational systems in development is the key to understanding cognitive development. Finally, she believes that the basic mechanism for creating new representations is the Quinian bootstrapping process (in which new sophisticated conceptions are formed from simple ones).

Language is essential for science teaching. Learners come to school with preconceived notions about natural phenomena gained via experience (Carey, 2000; Vosniadou, 1994). Students are exposed to new experiences through science education, which drives them to adapt their mental models and develop them into scientifically valid conceptions. Language is a key instrument for encouraging this reconstruction (Kempert, Schalk, & Saalbach, 2019).

Carey makes three claims: The first is that there are two kinds of knowledge, or working representations of the experienced world. The first category is mediated by what Carey (and others) refer to as core cognition mechanisms. These mediate the implicit representation of the world in the behavior of learners. They did not distinguish between what we now call heat and what we now call temperature. They couldn't understand how a temperature difference causes

heat to go from a higher temperature source to a lower temperature source because they didn't distinguish between temperature and heat. As a result, she claims, our understanding of these two distinct primitives cannot be articulated in their language. According to the new conceptual change theory, it posits that for new scientific understanding to happen students need to reorganize their schemata to accommodate the new knowledge. Thus, teacher educators need to work with students' prior knowledge so that they can help them to transition to new information smoothly and create opportunities to learn. This study argues that teaching and learning are social processes. The social-cultural theory of learning resonates with this study because of the nature of teacher educators' communication that serves as a tool to promote further engagement of pre-service teachers in science lessons. This study is supported by social constructivist theory.

2.3 Learning

Learning, according to Scott (2008), should ideally engage students in generating connections between every day and scientific viewpoints by enhancing awareness of parallels and differences between the two. This is regarded as meaningful learning by Scott (2008), as opposed to rote learning, in which the scientific viewpoint is linked to memory but is not integrated with preceding conceptions. Active construction of meaning is dependent on one's prior knowledge rather than the passive acquisition of it (Osborne & Wittrock, 1985). The creation of understanding can happen both through individual and group interaction (Driver et al., 1994). Rich and domain-specific conceptual knowledge is developed by integrating prior knowledge with domain knowledge. The practice of science becomes rote learning (Roth, 1990) unless prior knowledge and specific disciplinary knowledge are linked and interconnected. By connecting new material to experience or parts of the new material, analogies, metaphors, problems, and other devices can enhance the understanding of science (Wittrock, 1998). For instance, Wong (2017) demonstrated the effectiveness of self-generated analogies in enabling individuals to refine their scientific conceptual understanding through the generation, evaluation, and modification of their statements. According to Clement (1988), analogies come spontaneously when solving scientific problems. Scientific explanations play a crucial role in understanding how and why something happens. Students who perform better when giving their contributions (i.e., those that naturally arise) when reading science texts (Chi et al., 1994) have been shown to demonstrate greater problem-solving abilities. Meaningful learning is addressed in the next section.

2.3.1 Meaningful Learning

Ausubel's theory is concerned with how individuals learn huge amounts of meaningful material through verbal/textual presentations in a classroom setting. According to Ausubel, learning is dependent on the kinds of superordinate, representational, and combinatorial processes that occur during information reception. Subsumption is a key process in learning in which incoming material is substantively and non-verbatimally connected to relevant ideas in the existing cognitive framework. Cognitive structures are the residue of all learning experiences; forgetting occurs when some features become integrated and lose their unique character.

A major teaching tool proposed by Ausubel is the use of advance organizers:

Ausubel highlights the distinction between advance organizers and overviews and summaries, which simply highlight significant ideas and are provided at the same degree of abstraction and generality as the rest of the material. Organizers serve as a link between new learning material and pre-existing ideas (Ausubel, 1968, 1978).

> "The most persuasively voiced criticism of advance organizers is that their definition and construction are vague and, therefore, that different researchers have varying concepts of what an organizer is and can only rely on intuition in constructing one--since nowhere, claim the critics, is it specified what their criteria are and how they can be constructed" (Ausubel, 1978, p. 251).

Another criticism leveled regarding Ausubel's advance organizers is that they are frequently compared to overviews. Ausubel, on the other hand, has addressed the issue by stating that advance organizers differ from overviews "in being relatable to presumed ideational content in the learner's current cognitive structure" (Ausubel, 1978, p. 252).

Finally, critics question if advance organizers are designed to benefit high ability or low ability pupils. According to Ausubel, "advance organizers are designed to favor meaningful learning." Ausubel (1978), p. 255. As a result, the question of whether advance organizers are better suited for high or low ability students is irrelevant, as Ausubel contends that advance organizers can be tailored to any student in order to assist them in bridging the gap between what they already know and what they are going to learn. Ausubel (2012) suggests that knowledge-building or construction affects conceptual understanding. Understanding conceptually refers to the student's ability to internalise the interlinked concepts within their mental structure. Learning and Concept (1998) says, meaningful learning is the ability to relate new knowledge

to pre-existing knowledge. Learning materials should activate learners' cognitive structures by making conceivable connections between new and pre-existing knowledge (non-arbitrary). The real-world connections between scientific explanations and real-world phenomena should be apparent to students every day, as should the connections between scientific ways of explaining and scientific concepts. Meaningful learning materials should be available to students that go beyond words. Novak (2002) proposes that valid meanings must be constructed to understand meaningful learning (Ausubel, 2012). To reduce verbalisation of content, mode of representation, analogies, and moving between different scales and levels of explanation should be utilised (Ausubel, 2012). Misconceptions should also be addressed by using the platform of representations, analogies to bring clarity to meaning making process.

As defined by Konicek-Moran and Keeley (2015), conceptual understanding refers to learners' capability to develop their conceptual understanding, apply different conceptual understandings to different situations, describe a conceptual understanding in their own words, and construct a mental representation of a conceptual understanding. However, how learners organise their thoughts have a considerable impact on their ability to internalise or conceptualise information.

A learner's conceptual understanding is informed by interrelationships associated with concepts (Ausubel, 2012). The concept of conceptual understanding has been defined by Konicek-Moran and Keeley (2015) as the capabilities learners possess to think about a concept, use a concept in different situations, and explain a concept in their own words, as well as construct a mental representation or model of the concept. The organisation of thoughts, however, has a considerable impact on the ability of students to internalise or conceptualise ideas.

The learning process requires an organisation and conceptually rich learning material to produce meaningful learning. (Novak, 2010). Therefore, learning materials should follow a coherent order. Regardless of how well a subject matter is organized, the teacher is still responsible for guiding learners. Organising concepts systematically and coherently can lead to meaningful learning. A carefully designed curriculum should allow learners to see and make connections between interrelated phenomena and coherent scientific concepts, according to the National Research Council (2012). This type of curriculum can help students gain a continuous understanding of concepts (Krajcik et al., 2014). In the teaching and learning process, whether the learning materials are organized correctly and if the content is conceptually rich matters (Novak, 2010). It is therefore important that the learning material is coherently arranged.

Meaningful learning can only occur when concepts are organised in a systematic way. According to the National Research Council (2012), the curriculum must be carefully designed so that learners will be able to see and make connections between scientific phenomena and science concepts if they are to develop deep, interconnected understandings of science. Learning from such a curriculum is associated with continuing conceptual growth (Krajcik et al., 2014). My study aims to examine how teacher educators use the pedagogical tool of discussion to foster dialogue and open up opportunities for learning life sciences concepts in a science classroom. The teacher educators must be acquainted with the subject matter or content to be taught. According to Sirhan (2007), experts (teachers and curriculum developers) should be in charge of structuring educational content in an organised manner. According to Vygotsky and Cole (1978b), learners should not only be shown the links but should also be involved in identifying them socially (classroom discussion).

According to Fortus et al. (2015), incremental learning allows learners to develop their understanding of new concepts over their prior knowledge. By presenting logical connections between concepts in a sequenced manner, the authors go on to explain that good design can aid learners in building conceptual understanding. New ideas and old ideas are refined to form concepts. Nevertheless, students do not always establish these links on their own (Sirhan, 2007). Teachers and peers with more knowledge should help students make these connections. The most effective way to accomplish this is through meaningful social interaction rather than rote learning. Organising concepts and topics coherently facilitate new learning and provide a context for relating prior knowledge with new ones (Selvaratnam, 1993). Hence, my study sought to understand how teacher educators facilitate opportunities to learn life science concepts in their classrooms. According to Novak (2010), education theory has five components: learner, teacher, knowledge, context, and evaluation. The learner element is described essentially along the lines of Ausubel's assimilation theory, based on research. The development of new knowledge according to Novak (1993) occurs through creative individuals (educators) who provide a platform and creativity in their instructional delivery for higher levels of learning. Teacher educators can do so by facilitating interactive learning, such as engaging their students with mind-engaging activities that provide opportunities for the students to take responsibility for the interactional process. Meaningful learning according to Novak (1993) encompasses the physical environment, the social environment, and the structure of an event, so a context element was utilized to encompass the totality of the social plane the instructional artefacts, and the cultural setting is to be utilized for learning to be meaningful. Finally, evaluation informs both the student and the teacher educator about the level of mastery

of new meanings. For all five of these elements to be effective, they must empower students to be more effective in the short and long term. the elements of learning as posited by (Novak, 1993). The learning process should encompass how the learner feel and cognitively engage with the content of instruction, how the educator facilitates the learner's motivation to interact all builds the process of meaningful knowledge negotiation.

2.4 Teaching and learning Biology

Teacher education refers to an environment for the training of preservice teachers where skills and professional knowledge directs the activities and interactions in this social space (Akyeampong, 2017). Specialised knowledge required for teaching preservice teachers differs from the knowledge for teaching disciplinary content argued (Berry, 2008). Hence, teacher educators must have both professional knowledge and subject matter knowledge in order to teach preservice teachers. Therefore, science teachers' educators require a highly integrated picture of science knowledge, as well as awareness of key science ideas, in order to teach for understanding. Teacher educators face a difficult task in preparing their preservice teachers to be good teachers (Loughran, Berry, Mulhall, & Woolnough, 2006). This is because the teacher educators must prepare preservice teachers to learn about teaching and as well as learn the subject matter. This dual role places a demand on the professional knowledge of teacher educators. Teacher educators need to provide opportunities for preservice teachers as students of teaching with instructions and actions about teaching. Burn and Mutton (2013) argued that the practice of teaching should involve expert teachers of teaching. This means teacher educator who are experts in their field should expose their preservice teacher to the knowledge for teaching which is different from the subject matter knowledge required to teach course content.

For a biology teacher educator, this entails assisting pre-service teachers in acquiring teaching knowledge, regardless of whether they are enrolled in a content or methodology course. According to Loughran (2006), a teacher educator must assist pre-service teachers in acquiring knowledge related to these two learning needs (learning about teaching and subject matter) because this is what distinguishes preservice from other students. Kafka-Markey (2018) argued that teachers must have a broad range of knowledge to handle their challenging practice of preservice teacher preparation. The process of internalising (Vygotsky, 1978) what students are exposed to for the first time in the lectures called conceptual tools is voiced out or communicated through opportunities that are made available by the teacher educator. The understanding of what knowledge students are exposed to is significant in enabling learning. Novak (2010) and Ausubel (2012) posited that learning in a meaningful way is only possible if new information is relevant to previous understanding thus it becomes vital for educators to link new knowledge to students' prior understanding. A constructivist view of learning, as Fosnot (2013) explains, is "a teaching practice that provides students with concrete, contextually relevant interactions from which they can look for trends, pose questions, and model, interpret, and defend their claims and ideas" (Fosnot, 2013, p. 4).

As a result, constructivist teachers are more concerned with developmental processes and inspire students to question why things are the way they are (rather than those who are primarily concerned with their students learning scientific rules or laws). McGregor (2007) also describes how retention, understanding, and the active use of knowledge can be brought about only by the learning experiences in which learners think about and think with what they have learned. However, this happens only in the learning environment that encourages learners to reflect on and apply what they've learned. Likewise, teacher educators should use pedagogical approaches to involve students beyond a limited understanding of learning biology, ranging from a focus on material or factual knowing-what to a focus on thinking about things and reasoning why. They are, for example, thinking about possibilities and how to solve practical challenges and design solutions, as well as practising knowledge creation. McGregor (2007) elaborates on this by highlighting several variables that influence the cognitive processing that students who are encouraged to participate in. She also shows how educators can use pedagogic strategies to affect and promote cognitive growth by posing intriguing concepts, asking thought-provoking questions, assigning difficult tasks, and focusing on any outcomes. It is also the teacher's pedagogical values, according to Mercer and Hodgkinson (2008) that determine activities (i.e., the decisions they make on how they interact with their students and the methods they employ) that shape the way they think. As a result, the ways that pedagogical enactments develop in the classroom are informed by the teacher's perception of the theory of the teaching process. How students engage in thought will be influenced by how they sequence and ask questions, promote discussion, and mediate without giving away any answers (McGregor, 2007). The importance of ‘doing' and ‘talking' (through small groups of students solving problems together) becomes more prevalent and pedagogic ways of promoting definite encounters.

Students are assisted in active and interactive participatory learning by Vygotskian notions of social construction (McGregor, 2007). As Mercer and Hodgkinson (2008) point out, teachers must critically consider not only their questioning strategy but also their mediation and scaffolding techniques to foster students' reasoning rather than merely instructing them.

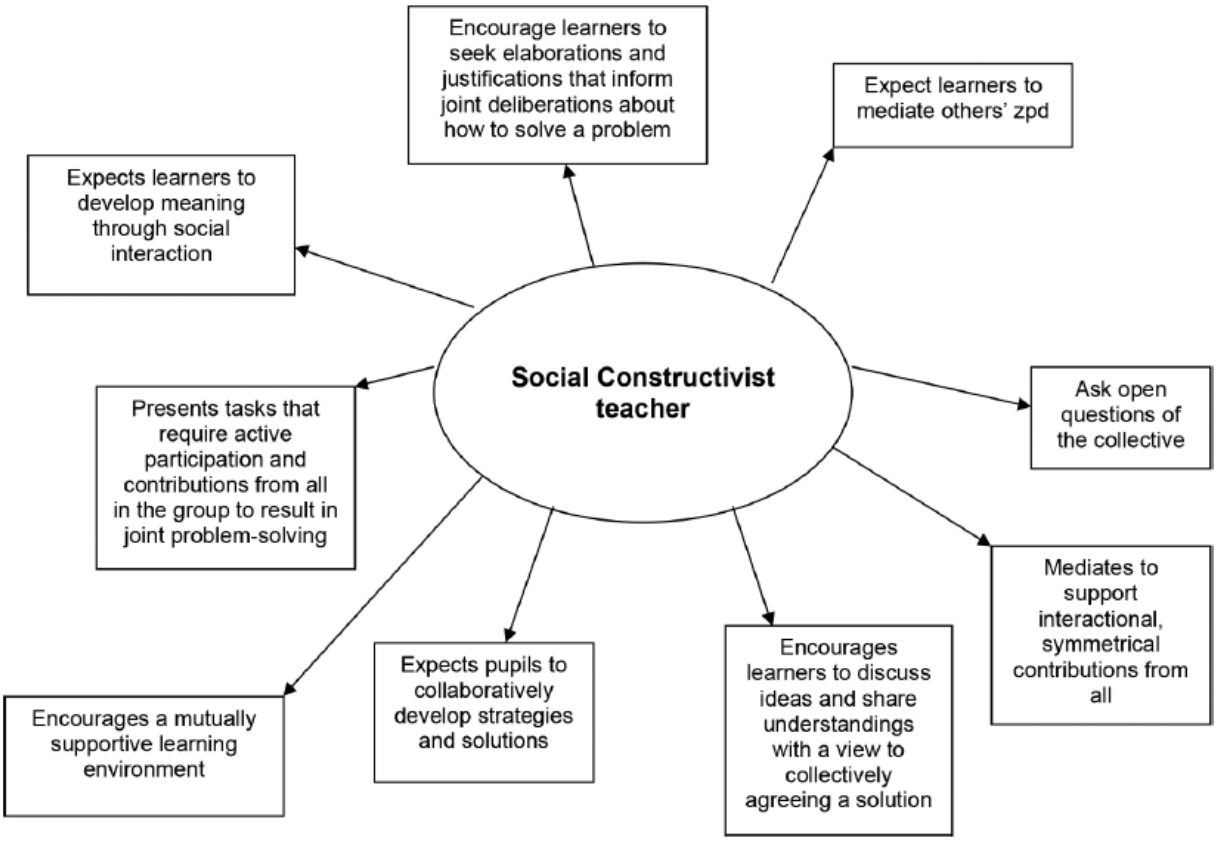


Figure 2.1 Demonstrates teacher behaviours in a science classroom

Fig 2.1 above demonstrates teacher behaviour in a science classroom; this is supported by the constructivist view of teaching and learning (adopted from McGregor, 2007). Preservice teachers are encouraged to better understand what it means to teach science from a constructivist perspective as part of the lecture delivery through modelling. For some time, constructivist studies have demonstrated that learners bring their prior views of science to the classroom based on how they conceptualize specific concepts and ideas (Oliver,2000). Constructivist teaching is based on the teacher acknowledging and identifying students' alternative conceptions, as well as creating experiences and opportunities for them to experience conceptual development over time as explained above.

2.5 Teaching and learning Biology in teacher education

Ghousseini et al. (2016) argued that preservice teacher preparation is a complex process. This stem from the dual role of teacher educators of both teaching preservice teachers as students as well as future teachers. Russell (1997) submits it as educators and preservice teachers practising the 'content turn' and the 'pedagogical turn'. Hence, teacher educators teach the course content and the methods or strategies employed in the practice of teaching. This clearly, defines the complex role of educators play in thinking approaches to facilitate learning and also

representing their practice to preservice teachers. Therefore, both teacher educators and pre-service teachers must be cognizant of how knowledge is generated (Korthagen et al., 2005). Teacher educators are not only teachers who teach, but also teachers who teach about teaching. Because the pedagogical turn involves the teacher educator consciously thinking about his or her approaches and teaching styles, this must be communicated to teaching students (Loughran, 2007). Next, I discussed biology teaching using the sociocultural approach.

2.5.1 Teaching & learning Biology using a sociocultural approach

According to (Cakir, 2008) when students are actively engaged in the teaching and learning environment, they learn. This places a demand on teacher educators to employ teaching strategies to actively engage preservice teachers with opportunities to learn. These strategies are aligned with the sociocultural theory employed in the study as developed by (Vygotsky, 1978). A goal of teacher education programs should be to teach content in a way opportunity to internalise the experiences accorded to students. Opportunities to learn in science classrooms are provided by teacher educators through the medium of activities and interaction. However, what students bring to school often differs from what they should learn at school, but when what students already know is joined with what they are learning; classroom learning is considerably enhanced (Vygotsky, 1978). The notion of prior knowledge is vital to the sociocultural teaching approach. Teacher educators' knowledge of preservice teachers' prior knowledge will help in designing and employing strategies that facilitate interactive engagement for concept development. To teach preservice biology concepts by working with their prior knowledge, teacher educators employ questioning (Chin, 2007). The use of questioning by teacher educators places a demand on their skill of understanding and use of prior knowledge to build new understanding. The ability of a student to get a better understanding of content knowledge becomes less difficult as he or she interacts with more knowledgeable others and must work hard and responsively across time and situations to close the gap between everyday ideas (student acquisition of prior knowledge) and science concepts (student mastery of academic information) as these two forms of knowledge develop.

Social interaction is important to the process to the process of learning or internalisation of content experienced by preservice teachers' science is created in the classroom (Cian & Cook, 2018) Hence, the teaching of biology should provide the preservice teacher with challenging activities to activate their cognitive structures and collaborate in the learning process. Teacher educators need to engage with contents and contexts employing different discourses (authoritative and internally persuasive) to better support students' concept development. The

teacher educators should engage preservice teachers to think, and the activities they are given should allow them to make meaning. As a result, they can use their schema to shape knowledge gained from activities (Khoza & Nyamupangedengu, 2018). Sociocultural perspective of learning implies that knowledge is socially entrenched and that learning is mediated (Vygotsky, 1978), hence teacher educators as regarded as facilitators of the learning process. Similarly, Lemke (1990) describes talking science as a social activity and maintained that quality teaching is vital to student's conversation and learning. Teaching biology employing sociocultural perspectives means educators should employ tools to facilitate the process of meaning negotiation. According to Bakhtin, educators must transcend beyond the school's authoritative discourse, in which students must comprehend what the teacher has said (teacher telling is often an indication of this) and participate in the dialogue by engaging in contingent and reflective communication with others (Bakhtin, 1981). This resonates in the teacher education context, where my data was generated. In the context of preservice teacher preparation, teaching and learning in lectures are to model teaching that engages students in social interaction by way of conversation and prepare pre-service teachers for their future deployment in diverse South African classrooms. Lectures are usually delivered to large groups of students who are involved as such dialogs becomes the predominant mode of communication. Research shows that, if used effectively, conversation can lead to interaction and engagement, especially in science (Msimanga & Lelliott, 2012). Several studies investigate the role of dialogue in high school science classrooms (for example, the work of McNeill & Pimentel, 2010). However, there has been little investigation as to how educators facilitate social interaction in the classrooms of higher education, specifically teacher education (Lehesvuori et al., 2013; Peters, 2010). My study is therefore aimed at contributing to debates on the necessity of engaging in meaningful social interactions as platforms for opportunities to learn science concepts during pre-service teacher preparation and education.

2.6 Interaction in a science classroom

Science classroom interaction according to the sociocultural perspective entails an orchestration of science content teaching for students in lecture spaces. This content teaching is facilitated by the teacher educator as he/she designs the teaching sequences for his students (Leach & Scott, 2002) with relevant activities for the unit of a particular lesson. To support students to internalise the new concepts introduced by the teaching interplay, the educator develops the scientific story in the social plane (Ogborn., Kress, & Martins, 1996). In the process of content delivery, the educator opens spaces for students to engage with content as

such hence control of the interaction in the learning space is a shared activity hence it can happen in different unpredicted moments. This classroom interaction could happen between student-content, student-teacher, and student-student. Interaction between the student and the material or topic of study is a distinguishing trait of schooling. It is this type of interaction that I believe is at least partly involved in what Grooms (2018) Calls the "internal didactic conversation" when students "talk to themselves" about the information encountered in the classroom. The form of interaction is a result of an individual working alone with content where content may be in the form of text, pictures, diagrams, or something concrete like a model. Interaction between the students and the educator (in the case of a whole-class discussion) seen as a more knowledgeable other who prepared the subject material, or any other material, is considered important by many educators and highly desirable by many students (Sutton, 2013). Teacher educators strive to reach aims held in common with all other educators in this interaction. They attempt to stimulate or at least sustain the interest of the student in what is to be learned, to inspire the student to learn, to enhance and maintain the interest of the student including self-direction and self-mindedness, first having prepared or provided a curriculum, a program of content to be taught. Similarly, Moore and Kearsley (2011) argued that Interaction can happen between a teacher educator, one student, and other students, alone or in a group in the environment. Hence interaction is a social activity however the interaction that happens between student-content. On the other hand, Wagner (1994) describes the interaction as an occurrence taking place between students and their environment. Wagner does not, however, go on to describe what makes up the environment of students. I accept Wagner (1994) and for my study, the environment embraces the teacher education context, teacher educators and their students (pre-service teachers), and the knowledge base of the study being the topics selected to generate data. The basis of interaction in the whole class setting is engaging students in cognitively demanding activities through the use of PowerPoint presentations, worksheets, and models, as tools of teaching. The idea of Vygotsky on how people learn is frequently referred to as social constructivism. According to social constructivist teaching methods, knowledge is a socially negotiated good. "Words and concepts do not have intrinsic meanings aside from those established and negotiated by individuals in particular circumstances," one such approach states (Hyslop-Margison & Strobel, 2007).

Social constructivism rejects the notion that human cognition serves as the only source of information and supports the idea that knowledge is a cultural or negotiated product produced in collaboration and understanding with others.

The educator approaches learning from a social constructivist perspective, by designing activities that guide students toward topic mastery and that encourage a certain degree of cultural assimilation; social constructivism avoids the concept that individual cognition is the only factor in knowledge views and continues to play a significant role in the classroom. Vygotsky (1978) suggested that learning social norms and cultural tools is a major goal of constructivist pedagogy and a unique aspect of the human experience. The activities designed by teacher educators to engage their preservice teachers and the prompts and probes the educators employ to drive the process of interaction are platforms for opportunities for their preservice teachers to learn in the social space of the science classroom. Hence, teacher educators play a critical role in the process of provision of opportunities for learning by bringing their professional knowledge into the learning and teaching environment.

Although the literature suggests that higher education classrooms are not overly interactive spaces because of the student large population (Boating, 2012; Hurst et al., 2013) my argument is that interaction happens in higher education classrooms. However, these interactions in the higher education learning spaces will be the premise of how teacher educators engage the resources in context and their students. For example, teacher educators facilitate interactions in their classrooms as they engage their students with questions challenging their prior understanding (Chin, 2007; Ocbian, & Pura, 2015a). What is however necessary but lacking is effective interaction that leads to active engagement with the science content of the discipline. The intense active participation of participants in the science content of the discipline is a meaningful engagement (Azevedo & Sherin, 2012; Engle, 2012).

Next, I discuss the concept of scaffolding in the course of the teaching and learning process.

2.6.1 Scaffolding

“Scaffolding” as a metaphor for representing the assistance that a teacher or more experienced peer can provide in a learning context derived from Wood et al.’s work (1976). The word scaffolding has been introduced in teaching and refers to the assistance provided in an educational setting by an educator or more competent peer. The research aim of scaffolding was about discovering the essence of the nature of the support that the more competent other provides in the learning context (Wood & Wood, 2012). This is an element of the learner's "fine-tuning" support as part of his learning.

How teacher educators could successfully scaffold in the context of teacher education was debated (Black, 2007; Bliss et al., 1996; McCafferty, 2002; Wood & Wood, 2012). Lantolf

and Thorne (2006) remind us of the power vested in the teacher educators as part of their scaffolding role over time when the learner becomes able to perform something independently by being a more knowledgeable other. The adult can then teach other techniques to make things harder as puzzles. In an educational environment, through conversation, the teacher or a more able peer will provide scaffolding for this help. This study is interested in exploring the interaction between teacher educators and their preservice teachers and is enacted in a large lecture setting. Bruner (1978) writes of scaffolding as follows: "(it) refers to the measures taken to minimize the degree of independence in the execution of such activities so that the preservice teachers can focus on the challenging ability that it is in the process of learning" (p.73). The purpose of scaffolding is not to simplify the task, but to decrease the degree of complexity or ambiguity, to successfully accomplish the task. How teacher educators could successfully scaffold in a context of teacher education is through providing support context (Black, 2007; Bliss et al., 1996; McCafferty, 2002, Wood & wood, 2012). This study is interested in exploring the discussion between teacher educators and their preservice teachers as they enacted their lectures. My point, that the exchange used by teacher educators to scaffold learning is important. Such conversations can help grow a larger ZPD. By offering "a leading question" Vygotsky puts language at the centre of his claim on improving ZPD. Through social interaction between teacher and student, scaffolding in the process of education aims to advance the learner's "present abilities and knowledge to greater levels of competence." (Donato, 1994), with the goal of achieving "the upper limit of (his/her) ZPD" (Hammond, 2001) The instructor "closely monitor(s) student learning and intervene(s) to provide assistance as necessary" Offering "just enough guidance so that the learner can make progress on his or her own" (Wharton-McDonald et al., 1998). The teacher can gradually reduce the amount of intense help provided as the student internalizes new information and develops competency to the point where he or she can work independently at a higher level. The teaching interaction that happens between teacher educators and their preservice teachers provides a platform at strategic moments in the collaborative space (opportunities) for learning to happen. The support teacher educators provide by probing, prompt and extended elaborations with questions or review of students' responses or engaging students with their peers in sharing ideas in whole-class discussions are learning opportunities.

2.6.2 Mediation

Mediation is the use of auxiliary objects or tools during the execution of a task. The act of creating and using an accessory for physical, mental, or social purposes (Lantolf, 2009). Humans do not act directly on the physical world, as Vygotsky (1978) argued; rather, they create symbolic and physical tools (auxiliary tools) that (from my understanding) are passed on from generation to generation. As a result, we have many tools and devices that allow us to accomplish tasks more quickly, such as shovels, hammers, bulldozers, dynamite, etc. Similar auxiliary tools are employed within the social and psychological realms as well, for example, numbers, graphs, models, drawings, and linguistic symbols (Lantolf & Thorne, 2006; Karpov & Hayward, 1998). Our most common form of communication is through linguistic symbols, which is one of the most important forms of symbolic mediating our mental activity (Lantolf, 2009). Mediators must satisfy the zone of proximal development (ZPD) of the individual or the group to be effective (Lantolf, 2009). Using the metric of independent problem-solving or collaboration with more capable peers (1978), Vygotsky defines ZPD as a "gap between actual levels of development" (p.86). The classroom interaction that Vygotsky advocated is an effective method for teaching and learning, and a learner's ability to tackle a task successfully requires proper assistance. ZPD is therefore concerned with language learners, their characteristics, and the action they take during their learning process, which helps them achieve what was unachievable alone (Lantolf, 2006). Mediators need to know the accomplishments that an individual has already achieved, as well as what additional help or mediation can provide. Language, signs, and symbols are understood as psychological tools that mediate all forms of human mental activity, including learning science (Lantolf, 2011). Human interaction with other people and artefacts is mediated through a sign/ symbols system in (Swain et al., 2009; van Lier, 2000). As science learners, SCT does not consider them as producers of output or processors of input but rather as participants in developmental processes, which occur as a result of the interactions (Ohta, 2000). Humans become more mentally active through interactions with other members of our society (Lantolf, 2006; Donato & McCormick, 1994). Similarly, to Vygotsky (1978), Wagner (1994) believes learning occurs through social interaction: concepts arise out of an interrelated system that shapes and transforms one another. Therefore, learning is intrinsically a social process (Lantolf & Thorne, 2006). Another view of SCT is that science learning occurs in the context of joint activity (Vygotsky, 1978). Walsh (2006, p.159) believes learning to be His philosophy of "learning" is deeply rooted in a sociocultural milieu as he believes that it is not just about cognitive development but also

collective practices. A person must be active if they wish to learn, according to van Lier (2000, p. 259). Inborn capacities do not evolve through development but transform through the interaction of these inherent capacities with sociocultural constructed meanings (Lantolf & Thorne, 2006).

2.6.3 Peer interaction

Peer interaction can promote learning, hence teacher educators should provide a platform for students to assist their peers to internalize concepts and to provide them with support if the need arises (Donato, 1994). By creating a setting that allows for form and meaning to coexist, they aim to create mutual understanding (Donato, 1994) In addition, scaffolding can be utilized quite effectively by students who are sensitive to their ZPD, enabling them to improve communication and understanding (Lantolf & Thorne, 2006). Wood, Bruner, and Rose (1976) defined "scaffolding as those elements of the task that are initially beyond the learner's comprehension, but which allow them to focus on and complete only those elements within their control (Wood et al., 1976, p. 90)." the key to successful scaffolding is respect for peers' opinions, as well as trust (Stone, 1993). According to Olmedo (2003), peer interactions provide an excellent opportunity for learners because peers act as a mediator, interpreting and assessing their peers' communicative intentions and facilitating comprehension. Some interactions, however, are more likely to lead to learning' (Newton & Sorensen, 2010; Stroch, 2002). Collaboration, dominance, dominant-passive, and expert-novice are the interaction modes identified by Storch (2002). While students participating in cooperative interactions work together to complete tasks, students in dominant-dominant interactions do not take part in each other's contributions. An expert-novice interaction takes place when a more knowledgeable learner supports a less knowledgeable learner. In other words, dominating learners assume control of the task and passive learners act as subordinates. Collaboration and expert-neophyte are both interaction patterns with collaborative activities, whereas dominant and dominant-passive are non-collaborative. In general, the more collaborative and complementary the learning process, the more effective it is (Stroch, 2002).

Mortimer and Scott Model (2003)

Mortimer and Scott's (2003) model for analysing classroom interactions helped me to make sense of my data. The framework presents communicative strategies- The definition of "communicative approach," first introduced by Mortimer and Scott (2003), is fundamental to the process and offers a viewpoint on how the teacher interacts with students to generate ideas

in the classroom interactions. The communicative approach focuses on whether or not the teacher engages with students (either by taking turns in the discourse or merely delivering content), and whether or not the students' views are considered as the lessons progress. In expanding this element of analysis, four fundamental communicative approach classes were identified, which are defined by characterizing the conversation between instructor and students along two dimensions, dialogic-authoritative and interactive-non interactive.

The dialogic-authoritative dimension

Wertsch (1991) discussed the distinction between authoritative and dialogic functions, which Mortimer (1998) used to analyse discourse from a Brazilian classroom. It is founded on Bakhtin's (1981) concepts of authoritative and internally persuasive speech. (Wertsch, 1991, p. 73-74).

Dialogic discourse is characterised as being open to multiple points of view. Dialogic discussion necessarily takes on a distinct tone at different points in a sequence of science lessons. Thus, at the beginning of a class sequence, the scientific instructor might elicit students' everyday perspectives on a certain occurrence. Later in the sequence, the teacher may invite pupils to explore how to apply a newly learned scientific concept in an unfamiliar setting.

In contrast, authoritative discourse does not allow for the gathering and development of ideas. Here, the teacher concentrates on the school's science perspective. If students offer ideas or questions that do not add to the development of the school scientific story, they are likely to be altered or disregarded by the teacher. Alternatively, if a student concept is considered by the teacher as being beneficial to the advancement of scientific knowledge,

It is likely that the story will be grasped and exploited. In this approach, authoritative discourse is closed to the perspectives of others, with its direction predetermined by the teacher. More than one voice may be heard through different students' contributions, but there is no exploration of different perspectives, and no explicit interanimation of ideas, because the teacher does not take student contributions into account unless they are consistent with the developing school science account.

The form of the communication method used is affected by the emphasis of the lesson which can either be attributable to the purposes of teaching. It will then govern the kind of classroom discussion and allow for some interventions by teacher educators. The object of teaching may include exploring learners' ideas, developing learners' scientific content, engaging learners in

solving science problems as well as developing learners' conceptual understanding, and helping them how different concepts fit together. The content can either be everyday knowledge or scientific content that needs to be transferred to learners. This framework resonates well with Vygotsky's theory of social constructivism because it is useful in understanding how the teacher facilitates interactions and scaffolds student learning. Furthermore, it is useful in shaping the kind of communicative approaches used by the teacher in assisting students to understand science concepts. Mortimer and Scott (2003) believed that Interactive Authoritative Communication (IA) assist educator to employ students' view through question-and-answer routine to establish a scientific story in the course of teaching and hence establish the concept under discussion in a topic. Non-interactive/authoritative: The teacher presents a specific scientific concept and builds the scientific story or topic of discussion without involving student ideas. The patterns of discourse that play out in the classroom are created by various combinations of communicative approaches. Three principal forms of teacher moves are recognized by Mortimer and Scott (2003). Sinclair and Coulthard's (2013) initiation-response evaluation/feedback triadic discourse, also known as the conventional IRE/F triad, is the first and most common discourse from nature, authoritative. The triads are being replaced by more complex chains of utterances as discourse becomes more dialogic. A sequence of learner responses and teacher probing interventions follow a single initiate step in the closed IRPRP...E/F chain, resulting in a feedback or evaluation move by the teacher. In an open chain, on the other hand, the initiating move initiates a sequence of answer steps, with students responding to each other's contributions without or with limited teacher involvement. In a feedback or evaluation step, the open chain does not culminate. Hence, meaningful engagement is determined by the type of facilitation that teacher educators employ in their science classrooms to encourage interaction. Negotiating shifts between the different communicative approaches in the lectures generate tension due to exploration between prior knowledge and science content in lectures but evidence from the findings revealed that all teacher educators used the different communicative either to review students' ideas or to build the scientific story (Scott, et al., 2006). However, the teacher educator may take an authoritative communicative approach at other times, such as creating the scientific story, in which case her mediation will be all about choosing and forming ideas as well as testing the understanding of students. I discuss the elaborations that happen in lecture settings in the concluding section.

Teacher educators also employ elaborations as teaching activities in the course of their teaching. These are extended sessions probing using questions to check students' clarity of concept development over course of teaching time.

Indicators of the levels of elaboration are presented below.

The components of my analytical tool are not linear arrangements as presented in the representation below. The events during complex classroom interactions especially in large science classrooms require the teacher educator to shift between the different communication approaches in the course enacting their teaching as they build the scientific story as concepts are developed over time. The teacher educators engage in different types of interaction using power points tools to engage students with the content or involve students in activities that involve their minds to learn science concepts.

2.7 Prompt as triggers of opportunities to learn

Brown et al. (2008) argued that prompts are "Instructions, gestures, demonstrations, touches, or other things that we arrange or do to increase the likelihood that students will make correct responses." In the classroom, prompts include words, gestures, and instructions we use to increase students' likelihood of a correct response. The effective use of prompting permits students to learn while making negligible mistakes. Understanding the prompt hierarchy is important to using prompting in a manner that encourages students to learn independently to accomplish these activities. Thinking of prompts in terms of a hierarchy is helpful. The prompt hierarchy enables teachers to understand how different prompts may be invasive. The less the prompt is interfering, the easier it is to fade and eliminate. Questions and spoken instruction provide verbal prompts.

Pointing and other hand gestures that guide students in the right direction are part of a gestural prompt. A gestural prompt is to hold up two fingers to silence the class. When a student is about to give the correct answer, nodding and even looking in a direction that leads the student to a response are often gestural prompts.

Visual in daily life, visual prompts are popular. A visual in my study may complete the equation. Visual prompts can come in several forms in the classroom. Many learners profit from visual schedules such as a list to do where they can transfer completed activities to a column of "done". To direct students to the correct response, visual prompts may also be used (Walker, et al., 2014)

Modelling is done to show the right response for a learner while modelling. Worksheets that show an answer to one of the problems are a form of prompt modelling. The educator can also write something on the board, like an assignment, for students to complete correctly or discuss in pairs (Walker, 2008).

Physical prompt involves physical reminders, such as directing the hands of the student when a task is done. Students who have poor motor abilities or are unable to complete the task without this level of prompting should be limited to this level of prompting (Walker, et al., 2014).

Probing in lectures: probing are questions used to gather more insight into something or check students understanding in the course of interacting with students during lectures (Ocbian, & Pura, 2015a).

Elaborations in lectures: Extended sessions questioning of the preservice teacher by teacher educators during lectures in whole-class discussions. These elaborations could be in form of Breakdown, Sophistication, Individuation or Collectivisation

Breakdown: A situation where an incorrect suggestion is given by preservice teachers during the course of life sciences lecture

Sophistication: A situation where a correct life sciences suggestion is given by preservice teachers and is followed by a teacher's response that suggests a view of the offer as inefficient in terms of the student's response

Individuation - A situation where the whole class chant of a correct life sciences suggestion is pursued by the teacher educator to assess individual understandings

Collectivisation: A situation where an individual learner's correct life sciences suggestion is pursued by the teacher educator and shared in the collective classroom space.

Talking to a peer or in groups: Sharing of ideas and building confidence.

2.8 Conceptual framework

The process of developing a conceptual framework is similar to an inductive process in which small individual pieces (concepts) are put together to convey a larger story of possible relationships. In the same way that a theoretical framework is derived from a theory, a conceptual framework is derived from concepts. Consequently, a conceptual framework represents the researcher's synthesis of the literature to explain a certain phenomenon. It specifies the steps that must be taken throughout the research process based on the researcher's

knowledge of the literature review. A conceptual framework is a textual or visual portrayal of a variable's expected connection. Variables are the qualities or properties that you want to investigate. As McGaghie et al. (2001) put it: the conceptual framework "sets the stage" for the presentation of the specific research question that drives the investigation being reported based on the problem statement (p. 923).

The problem statement describes the background and the concerns that prompted the researcher to conduct the study. Therefore, the conceptual framework is embedded within a much larger framework known as the theoretical framework. Time-tested theories support the latter, which consolidate the findings of many researchers on why and how certain phenomena take place. "A conceptual framework explains, either graphically or in narrative form, the main things to be studied – the key factors, constructs or variables – and the presumed relationships among them." (Miles & Huberman, 1994, p.18)

Likewise, Varpio et al. (2020), posited that a conceptual framework: defines the state of known knowledge, usually from a review of relevant literature, identifies gaps in our understanding of the problem; and outlines the methodological procedure of the research. Hence, the conceptual framework is the pictorial representation of the problem of the study. In framing the study, the researcher identifies the key concept of the study and explains the connections among the concepts, and therefore, links to the problem statement which was teaching and learning of life science pre-service teachers in this study. A conceptual framework is created based on the flexible understanding of the researcher hence a conceptual framework aims to help us understand phenomena rather than to predict them.

In the study, it is assumed that learning occurs as a result of the explicit mediation of other, more knowledgeable individuals (teacher educators) of life science content to be learned and the student (preservice teachers). The more knowledgeable practitioner can help students internalize the content that already exists in the community of practice (Lave & Wenger, 1991) to which they aspire to belong (in this case, the teaching education community) so they can become fully-fledged community members and not just peripheral participants. Based on work on sociocultural learning theory (Vygotsky, 1978), cognitive apprenticeship theory is the basis for this particular assumption (Lave & Wenger, 1991). Hence, the conceptual framework for my study is provided below.

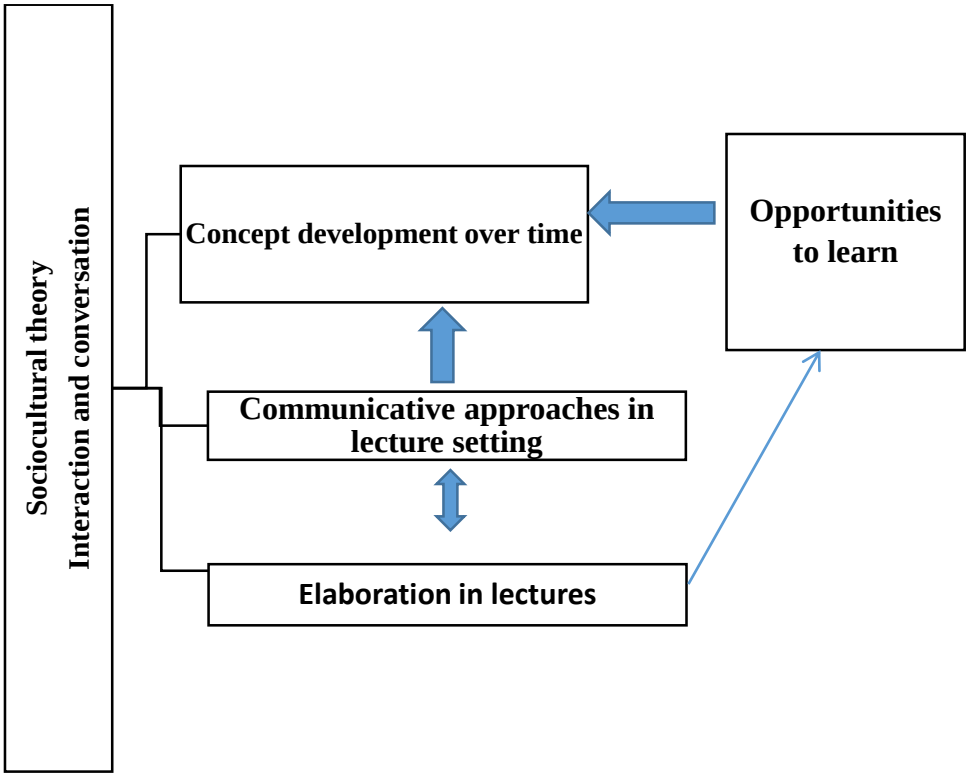


Figure 2.2 Conceptual framework for my study

The sociocultural framework that guided the study, suggested that skills and concepts are learned in meaningful and interconnected contexts rather than in isolated and hierarchical ones. Learning develops over time when prior knowledge is transformed in response to new information and old knowledge is challenged. The main goal of this research was to investigate how teacher educators create opportunities for learning life sciences concepts in their lectures. Thus, the conceptual framework is the visual representation of teacher educators' practice in life sciences lectures. In the course of lectures, teacher educators employ conversation and artefacts to open up spaces of interaction. According to Vygotsky's (1978) socio-cultural perspective, learning is defined as the internalisation of social interaction. The socio-cultural perspective places more emphasis on the social plane, where ideas are discussed and learning is triggered by social exchanges such as gestures, words, talk, visual images, and action. The emphasis in the socio-cultural perspective is on collective activities undertaken by teacher educators and students, or by students among themselves, within the context of the classroom; collective activities will be undertaken by the teacher and student(s), or by students among themselves. To heighten interaction with large student population teacher educators, employ different communicative approaches they engage their students while facilitating and giving responsive elaborations to preservice teachers' contributions. These communicative approaches could be interactive authoritative or interactive dialogic communicative approaches. Teacher

educators facilitate the creation of opportunities for learning generally by questioning, prompts and soliciting students' responses, and use of classroom resources (artefacts). Students engaged with their teacher educators in the social plane by responding to questions. Learning opportunities are provided as indicated by the arrow from either elaborative response of educators or communicative approaches. Finally, concept development happens when experiences in the social plane are internalised over a period of time by preservice teachers. To adapt the model for my analysis I took three components of the opportunities to learn model which are concept development, Communicative approach, and opportunity to learn and I brought in the elaboration framework. I selected and modified aspects of the two models to foreground opportunities created by teacher educators in a lecture setting.

2.9 Linking theory, to the research problem and research questions

In this section, I describe how the theory that guided the study helped me to address the study problem represented by my research questions provided below.

How do biology teacher educators create opportunities to learn life sciences?

1. How do biology teacher educators facilitate the creation of opportunities in their lectures?

2. What is the nature of pre-service teachers' engagement with opportunities provided by educators?

3. What evidence of pre-service teacher learning can be gleaned from their engagement with learning opportunities in lecture settings?

I drew from sociocultural theory, opportunities to learn model and elaboration framework to answer the research questions for my study. The use of conversations was viewed by the researcher as a medium to create opportunities to learn through social interaction on the social plane of the classroom and to mediate the learning of preservice teachers in the process of learning life sciences concepts. I, wanted to understand how teacher educators can facilitate interaction in the whole class with a large student population and engage preservice teachers with science concepts through interactive processes. Hence, my study was focused on three problems, the first problem was focused on the teacher educator's practice of facilitation of opportunities with a large population of students and how the interaction was stimulated to provide preservice teachers with the opportunities to participate and engage with life sciences concepts. I needed to understand how the teacher educators shape the interactions facilitated

that will eventually translate into internalisation of the science concepts preservice teachers encounter in the social plane of the classroom during lecture delivery.

The second problem has to do with the type of interaction that happens between educators and preservice teachers and the content delivery in the classroom. This problem was focused on the quality of engagement created by the opportunities for educators to guide the preservice teachers through the process of meaning negotiation. I sought an understanding of the approaches employed by educators to mediate the process of meaning negotiation with science content preservice teachers encounters in the course of lecture delivery.

The third problem of my study was the evidence of internalised concepts preservice teachers encountered in the course of lecture delivery as seen by the type and quality of their contribution in the course of interactions with educators, peers or artefacts in the social space of the classroom. In the third problem, I sought to understand how educators and preservice teachers negotiated the meaning-making process as mediation either by educators or more knowledgeable peers as they interact during the discussion in the science classroom.

2.10 Chapter Summary

In this chapter, I established a conceptual framework that guided my study, the theory of social constructivism, which stresses that learning, takes place within social settings. For students to make sense of the content; they have to get some sort of assistance from a knowledgeable person. To understand how teachers can make this possible, I explained the concept of social interaction and opportunities created by the participants for their preservice teachers to learn science concepts in the cultural community. In the next chapter I discussed the research design and methodology for this study.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction and Overview

The research explored how teacher educators facilitate interaction and create opportunities for learning science concepts in their lectures in higher education programmes as mentioned in chapter one. In this chapter, I described the study design and methodology employed for the study.

The main research question that guided the study was:

How do biology teacher educators create opportunities to learn life sciences?

1. How do biology teacher educators facilitate the creation of opportunities in their lectures?

2. What is the nature of pre-service teachers' engagement with opportunities provided by educators?

3. What evidence of pre-service teacher learning can be gleaned from their engagement with learning opportunities in lecture setting?

3.2 Research Design Adopted and Rationale

According to Thomas (2010), a research design can be equated to the master plan of a research project that shows how the study is to be conducted. It can be compared to a building design or an architectural outline of a building structure: "A research design essentially illustrates how the entire major parts of the research endeavour such as the population, samples, methods, instruments, etc. work together in an attempt to address the research questions" (Thomas, 2010, p. 308). This means that it is a comprehensive master plan that not only identifies and describes the various components of research but also how all the components work in harmony towards answering research questions.

In this study, I deliberately employed a qualitative case study design to gain an understanding of the phenomenon. The design employs methods of data generation involving interviews, lesson observation and document analysis to have a detailed view of the phenomena under investigation. I used an exploratory case study in which I adopted a multiple case study design

since the study involved an in-depth description of the processes of talk and interaction in the science classroom of teacher education.

As a relativist I strongly believe in the social construction of knowledge through human social interactions. As a relativist, reality is relative to the observer's perspective or the context in which they are assessed (Baghramian, 2004). I was convinced that a case study is appropriate to assist me in arriving at the findings of the study. Although the case study design is limited with regard to a generalisation of findings, I am sure the design has the potency to illuminate the phenomenon and provide a deep understanding of what, how, where, and why the findings are as they appear to be.

I intentionally used a qualitative case study design in this study to gain an understanding of the incidence. To be more specific, I used an exploratory case study with a multiple case study design because the study needed an in-depth explanation of the processes of talk and interaction in a science classroom for teacher education.

3.3 Case Study

This research explored teacher educators' practice as creating opportunities for preservice teachers to learn biology in their lectures. I adopted Yin's (2003) exploratory type of case study by using a single embedded design to explore the phenomenon because case studies are known to be outstanding in their ability to examine in-depth a "case" within its 'real-life' context (Yin, 2006). In this research, a case study provided a "thick description" (Holloway, 1997; Lincoln & Guba, 1985) of teacher educators' practice of facilitating talk in their lectures in a teacher education programme. "Thick description" refers to a detailed account of a phenomenon that includes the researcher's interpretation in addition to the observed context and processes.

Different authors have defined 'case study' differently, depending on their perspectives and orientation. This suggests that there is no universal definition of a case study; rather it is the author who adopts and provides the definition. I adopted Yin's (2003) definition of the case because the study investigated real people (teacher educators) in real contexts (teacher education) about a real phenomenon (how opportunities for science learning are created). My study is a multiple case study it allows the researcher to search for differences within and between cases. The cases are the four teacher educators because of the subtle differences to teaching my study is an exploration of their practice**.** The goal here is to duplicate findings through cases, in which the researcher can explore similarities and contrast between the cases

(Yin, 2003). This is similar to what Stake (2008) called a collective case study. Nevertheless, some renowned qualitative cases study scholars such as Sharan Merriam, Robert Stake, and Robert Yin have tried to provide definitions with relative common grounds. All these scholars agreed that a case study is a research approach that is 'bounded' (Yin, 2003; Stake,2008; Merriam, 2009). For example, Merriam (2009) defined a case study as, "An in-depth description and analysis of a bounded system" (p. 40), and she sees "the case as a thing, a single entity, a unit around which there are boundaries" (p. 27): The case can be a person, a programme, a group, a specific policy and so on. The researcher often makes claims of information based on coherence that is, based on the multiple sources of individual experience. Merriam acknowledged that case studies can be classified based on their intended purpose, such as descriptive, interpretive, or evaluative case studies. Descriptive case studies describe a phenomenon in detail without being guided by established or hypothesized generalisations. Descriptive case studies are also interpretive case studies. This implies that for a researcher to use case study purposes, intentions, and types should be clearly identified so that an in-depth description and interpretation of the phenomena is made possible.

Stake (1995) defined case study research as, "the study of the particularity and complexity of multiple cases, coming to understand its activity within important circumstances" (p. 6). This is a more flexible stance on a case study where the emphasis is on the rigour of the research processes with a particular focus on what is studied rather than how it is studied. This means the case is more important than the method of understanding the case. Stake used three terms to describe case studies: Intrinsic, instrumental, and collective case studies (Harrison et al., 2017). Intrinsic case studies are valuable to provide knowledge about distinctive cases. Instrumental case studies aid an individual to study more about an extensive issue. A collective case study can be useful for looking at several cases concurrently. I investigated the practice of teacher educators in a teacher education programme at a University. Therefore, my unit of analysis was all the participants' communication which includes conversation, gestures and visual prompts in lectures. The Unit of analysis answers the question of 'what' and 'who' is being studied in the research (Trochim, 2006). Even though my participants were teacher educators my unit of data analysis was their verbal communication as they engage with preservice teachers thus all interaction in creating opportunities by teacher educators becomes the unit of analysis. In this study, I foregrounded the views of Yin (2003 p. 145) concerning the conduct of this case study because Yin described a case study as a 'rigorous investigation that investigates the substance behind real-life situations, especially when the boundaries

between object and context are clear.' Case studies pay particular attention to contextual conditions in which something unique has occurred, often from the perspective of the people who experienced or are experiencing the unique phenomenon. I investigated teacher educators in their peculiar university context to obtain their opinions. My close observations with the participating teacher educators and their preservice teachers during lectures gave me ample opportunities to understand how opportunities to learn are created in their classrooms. Thomas (2010) believed that the "case study approach is especially useful in situations where contextual conditions of the event being studied are critical and where the researcher has no control over the events as they unfold" (p. 309). Similarly, this study focused on the contextual conditions of teacher educators enacting opportunities for social interactions in science classrooms. Case study research designs are classified into three types, according to Yin (2003): 'First 'When a researcher wants to answer a question that requires explanations on presumed cause and effect in real-life situations or interventions that are too complex for survey or experimental strategies, an explanatory case study is frequently used. Second. An exploratory case study is used to investigate phenomena where the intervention being evaluated does not have a clear, single set of outcomes. Finally, multiple case study design allows the researcher to investigate differences within and between cases; this design aims to replicate findings across cases.' I required a research strategy based on comprehensive data collection that would yield rich and detailed descriptions of teacher activities, as well as an investigation of the knowledge base to which these actions might be related in the context. I used what Yin (2003 p. 145) referred to as a multiple case study to accomplish this. "A multiple case study allows the researcher to investigate differences between and within cases. The purpose here is to replicate findings across cases so that the researcher can examine similarities and differences between them" (Yin 2003, p. 145). In this study the researcher examines the similarities and differences of the four teacher educators practice as they are the cases understudy**.**

Stake (2011) referred to this as a 'communal case study'. Yin also pointed out that since comparisons will be drawn between cases, researchers must take the time to select cases carefully so that they can predict the same results in all cases or predict comparison-based results. I provided extensive interpretation of classroom conversation and interaction as required by the learning process. Besides, I have provided a complete account of the methods and procedures that are followed while collecting the data and its aftermath (Thomas, 2010). I have also provided a thorough account of the critical strategies available to generate data for the study and explained all the choices and each decision I have made. Konicek-Moran and

Keeley (2015) posited that an outstanding strength of the case study design is in its "level of flexibility that is not readily offered by other qualitative approaches such as grounded theory or phenomenology" (p. 1). It is pertinent to note that the case study design is so flexible that it allows the researcher to make changes in decisions, choices, instruments, and strategies before, during, and even after the field study is conducted. In the next section, I provided the participant's information and their profile for the study.

This study explored how teacher educators create opportunities to learn. Since case studies are known for their ability to analyse a "case" in detail within its "real-life" background, I used Yin's (2003) exploratory method of a case study by using a single embedded design to investigate the phenomenon.

3.4 Participants

I purposively selected all year three life science preservice teachers and four of their teacher educators who consented to participate because they can provide an informed understanding of the phenomenon to be researched (Creswell, 2021). Purposive sampling is the careful choice of the participants for a specific cause or to represent a particular population, the researcher selects the participants according to his / her own decision, taking into account the intent of the study. Hence, the selection is critical of the methods to obtain the data, and to whom the data is to be made is reasonable, especially since no amount of analysis can correct the incorrect data collected. I selected four life sciences teacher educators (ensuring gender balance). In this study, the cases are the teacher educators and the focus was their practice of creating opportunities with a diverse student population to learn science concepts. My assumption in the selection was that the four teacher educators will bring their unique differences and similarities in the way they engage their preservice teachers in the course of their lecture delivery. The purposeful selection method, also called the 'sample of judgment' (Brown, 2015), is the preferred method of participation due to the qualities a person has. The participants willingly granted me access to generate data in their lectures. I selected participants based on the following criteria:

1) All participants were teaching life sciences as they have experience (Creswell, 2014); 2) I chose teacher educators working with preservice teachers in the research context. In addition, I wanted to study teacher educators working in similar situations as well: so that I can explore similarities and differences in their practice.

3) I needed teacher educators to be able to gather information about their teaching. Participants must have teaching engagement with life science three students and have a teaching qualification or be exposed to a teacher education programme.

Another rationale for the selection is for the researcher to work closely with the participant which according to Cohen, et al. (2000, p. 137) states that "…behaviour, and thereby, data are socially situated, context-related, context-dependent and context-rich. Hence, the researcher needs to comprehend the context because situations affect behaviour and perspectives and vice-versa" (Cohen, et al., 2000, p. 137) In this sense, I reflected that my working with the participants closely adds the basics of credibility to the data claims. This selection allows the researcher maximum use of a small sample for data generation Flyvbjerg (2006). To provide details of the phenomena this is an interactive exchange between teacher educators and their preservice teachers in the natural setting. In this study, purposeful and convenience sampling was used to identify research sites and research participants. All effort to protect the participants' identity through the use of pseudonyms was used to avoid the identification of the participants. All data was generated in one university so the context is the same for all the teacher educators selected.

Teacher demographic profile

Participants	Gender	Teaching in HE	Qualifications	Topic taught
Mr Jonah	male	Six months	B.Sc.Hons, MSc.Ed	Population ecology
Dr Charles	male	20 years	B.Sc. Hons, M. Ed, Ph.D. Environmental	Environmental studies
Ms Rose	female	16 years	B.Sc. Hons, MSc. Ed	Cell biology
Dr Lydia	female	12 years	B.Sc. Hons, MSc.Ed, Ph.D. Sc. Ed	Biochemistry of respiration

Table 3.1 A summary of the teacher educators' information

After receiving clearance from the Ethics Committee, the teacher educators willingly allowed me access to observe their lectures from where I generated my data. I also worked with them as a demonstrator in the Life Science Laboratory.

3.5 Data sources and methods

The data generation procedure took place over two years between 2017 and 2018. The researcher tracked teacher educators in their lectures to observe them with their preservice teachers. All four teacher educators were followed through an in-depth case study. Data collection sources for the study included: audio recordings of classroom observations of lectures, interviews, and documents (artefacts). The focus of the study is exploring the use of conversation to open up opportunities for learning science concepts for preservice teachers. In the following sections, I describe each stage of the data gathering. Literature advocates the significance of observations in educational research and shows that observations can help a researcher gather important information about what the teacher and learners do in the classroom. In this case, the observer (researcher) gets first-hand information about what is actually 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 (2009a), one can learn from observing others in their practice

3.6 Lesson observation

Observation is a method of observing and documenting events, activities, surroundings, individuals, and so on. A method of collecting data from organically occurring social settings. Watching and recording methods must be systematic Borg (2006). Borg argued that observational data provide "direct evidence of behaviour, is (in theory) non-interventionist, and enables for the collection of vast volumes of descriptive data" (p. 227).

Observations can help a researcher obtain significant information about the participants in the social context. According to the literature observations emphasizes the relevance of in educational research. Observation accords the (researcher) gain actual knowledge of what is going on in the context of the study (Bertram & Christiansen, 2014).

A total of 7 lessons from population ecology and environmental studies were observed between September and October 2017. In 2018 I visited two teacher educators' lectures in the first and the second block to generate data when they were teaching the different topics of introduction to cell theory and biochemistry of respiration. A total of fifteen lessons by four teacher educators were observed with two video-recorded preservice teachers' group presentations of assigned tasks. The number of lecture observations were different because of the duration of the topics being taught. Dr Charles and Dr Lydia taught three lessons each so I observed all the lectures of these two educators while Mr Jonah and Ms Rose it was five times.

To generate data for my study I observed four teacher educators teaching four different topics: population ecology, environmental studies, cell biology, and biochemistry of respiration. Population ecology and environmental studies have common concepts and areas of similarities they deal with the study of organisms in the environment and how different interactions of communities and populations impact the ecosystems. Also, the relationship between cell biology and cellular respiration is that understanding cell biology will help in illuminating challenging aspects of the biochemistry of respiration as respiration occurs in the cells of living organisms. Students have challenging misconceptions and difficulty understanding the myriads of concepts in the selected topics for observation to generate data.

The need to understand the area of alternative conception in predator-prey relationship carrying capacity of a population of the organism in a population is why the topic was selected (Kimberly, 2009).

The need to understand how teacher educators unveil the concepts of environmental studies with misconceptions and sustainability issues globally is a rationale for selecting the topic (UNESCO, 2014). Students areas of misconceptions about cell biology include the cytoskeleton in the movements of organelles, the flow of membranes and other materials between organelles and the shape of mitochondria and chloroplasts (Coley & Tanner, 2012). Cellular respiration is a topic taught in many settings, which includes secondary and undergraduate levels (Ummels et al., 2015). Cellular respiration introductory topic is needed to understand several other biological activities such as digestion and thus the need for its selection as one of the topics for my data generation.

Field notes and classroom observations of pre-service teachers allowed me to collect first-hand data from their group presentations. By observing directly, the activities of the pre-service teachers in the research contexts, I see first-hand; pre-service teachers talk and respond to changing circumstances and results of discussions during the lesson (Cohen et al., 2002).

3.7. Interviews

Qualitative research relies heavily on interviews to collect data. It is possible to conduct structured, semi-structured, or unstructured interviews (Farquhar et al., 2020). Structured interviews are much like questionnaires in that they will yield a relatively superficial level of response. Interviews conducted semi-structured usually involve a few predetermined topics with prompts to guide the conversation. The researcher follows the participant's lead in unstructured interviews and they cover a broad range of topics. There are a variety of interview methods, including in-person, telephone, and Internet. When a researcher desires to understand an individual's experiences or views in-depth, individual interviews are useful. The focus of the study was to explore how teacher educators facilitate opportunity creation for preservice teachers to learn biology.

3.7.1 Interviews with teacher educators

I conducted open-ended interviews and three questions were used to start the conversation and a few probes were used to generate a response from a participant. I wanted to hear from the teacher educators about their views on their practice and the communicative approaches

they employ in their lectures to facilitate life science concepts. Below are questions used to generate data:

- How do you use your lecture slides to engage your students with the content?
- What are the ideas of teaching and/or learning entrenched in your Slide designs?
- What would count as evidence that the lecture was successful for the topic of discussion?

Follow up question

I don't understand, please repeat your explanation

And then. These are probes used by the researcher to elicit responses from the teacher educators.

3.7.2 Focus group interviews

Focus group interviews involve interactions between a researcher and a group of participants as well as among group members and are used to collect information and insights in response to carefully constructed questions (McLean & Kramer, 2015). Because they "provide a comprehensive and complete set of data reflecting people's beliefs, ideas, feelings, and perceptions in their own words," focus groups are highly helpful in qualitative research (Dilshad & Latif, 2013, pp. 192-193). Darlington and Scott (2002) posit that interviews are the most commonly used method for collecting qualitative data mainly because interviews allow the researcher to have a deeper understanding of the phenomena at hand, from the respondents. Semi-structured interviews were selected as the means of data collection for the qualitative part of this study for the following reasons: firstly, semi-structured interviews were well suited to the exploration of the perceptions, conceptions and opinions of respondents regarding the impact activities on their learning from teacher educators. Secondly, the researcher wanted to bring first-hand information from students with regard to their perspectives on how c l a s s r o o m culture can influence learning. Focus group interviews were conducted with the pre-service teachers with a group of five students each to explore their perceptions about classroom dialogue and group discussion on tasks. I requested the students to declare their availability before the interview, and this helped to create the groups. I had three groups to interview at the conclusion. I informed the students that I would uphold the anonymity of their participation. My participants' understandings knowledge and views are meaningful properties of the social reality which my research questions are designed

to explore. To generate data, I interacted with my participants; however, this interview may add dimension to a form of methodological triangulation to see how interview data will corroborate with my observation data. Also to represent the perspectives of teacher educators and pre-service teachers fully and fairly. The focus of this study is how teacher educators create opportunities for social interaction in their lectures and learning of their preservice teachers was facilitated. So my interest is to identify occurrences of social interaction between both teacher educators and preservice teachers and how it can create learning opportunities. I audio-recorded all my observations of lectures as I was one of the demonstrators assisting lecturers with practical and tutorials for preservice teachers. I normally transferred the recordings to an external hard drive. Students were invited to share their experiences in their whole class interactive session with their consent. Students not willing to participate were encouraged that lack of participation will not affect them in anyway and their identity for participating students will be anonymised. The participants were assured that group information will be kept in confidence. The students that consented were divided into groups of five. I asked them to indicate their availability for the process. I employed a transcriber to assist me to save time. However, I transcribed all the audio audio-recorded interviews and some of the observations audio into text. In the next section, I discuss how I analysed the data for the study.

3.8 Analysis of data

3.8.1 The analysis of teaching transcripts

I audio-recorded all the lectures I observed from the lectures of the four teacher educators. This was to help me provide evidence for the study. The analysis of data was done in the steps that I describe below.

Step one

I transferred the audio recording to my personal computer and an external hard drive as a backup. I transcribed the audio-recorded interview while I employed a transcriber to assist me with part of my data transcription. The transcription was done verbatim.

Step two

To familiarise myself with the data generated I read through the teaching transcript to understand how teacher educators create opportunities for preservice teachers to learn (Attride-Stirling, 2001). I read the transcript several times to help me make sense of the data.

Step three

Having familiarised myself with the data I coded the data. Coding the data was informed by my conceptual framework of the study. I sought occasions in the lectures where interaction between teacher educators and their preservice teacher provided an opportunity for engagement with life sciences content and discussion in the whole class or amongst peers. The initial codes yielded sixty-three codes. Below is an example of a coded excerpt from one of the teacher educators, Jonah.

7 Any other contributions? (TE ask for additional rejoinder for clarity OTL

8 How do you differentiate it from community ecology? TE ask for an additional response for clarity OTL

9 But why do we study population ecology or ecology? Or, why do ecologists study ecology or population ecology? TE ask a question to the class and a follow-up question to elaborate on the initial question OTL

10 …But why are you saying sustainable development? TE ask for an additional elaborate meaning OTL

11 So, if we talk specifically about the human population, we are looking at how resources are distributed. TE reviews a student's response and further explains the concept. OTL

12 So, by knowing that Wits School of Education we have 3000 students…that is the population on this campus…so they know how they can distribute the computers and everything. TE further clarifies that knowledge of population concept will help in resource distribution. OTL

13 I told you that I will show you the levels of ecology. So, it ranges from organismal ecology to global ecology. With the organism, we are looking at how the organism responds to temperature exchange. So, it is about the behaviour and physiological features of that organism. TE further explains the levels of ecology using a PPts slide OTL

14 So, the question here would be how the population decreasing or increasing is and based on what? TE asks preservice teachers what causes a population of the same species to decrease or increase. OTL

15 Those we call the levels of ecology but the focus is now on population ecology. So, we have said that ecology is the study of organisms related to one another and their environment

and populations are organisms of the same species that live together at the same time TE uses PPT slides to illustrate a concept. OTL

Step four

The initial codes were refined and collapsed, into categories of seven broad themes. From the seven categories, I proceeded to analyse both deductively and inductively three remaining educators teaching transcripts. The analysis was inductive in the sense that I was open to new codes that may emerge from the remaining teaching transcripts of the three educators. Eighteen categories emerge all together for all the four educators observed. As part of the process of my validation, I gave two of my colleagues who have graduated, the transcript to code, to establish an agreement with my coded transcripts. Below is an example of categories that emerge from the initial codes of data of the study.

Categories of how teacher educators created 'opportunities for students to learn' emerging from teaching transcript

Category 1: TE introduces concepts with questions without providing answers explain TE

1 L: Now from Friday, what did we say is the key principle about biology topic was something that kept going back to as one of the key things you need to remember about biology and biological processes remember? I heard yes. Anyone remember? Anyone wants to guess?

S: Structure and function!

TE introduces concepts with questions without providing answers

34 What do you understand by population density?

TE ask the class a follow-up question

35Yes …So, what is density?

(TE repeats a question for the class to elaborate on the concept of population density. OTL…

Category 2: TE probes preservice teachers to elaborate meaning for clarity

7 Any other contributions?

TE ask for additional rejoinder for clarity OTL

8 How do you differentiate it from community ecology?

TE ask for an additional response for clarity OTL

9 But why do we study population ecology or ecology? Or, why do ecologists study ecology or population ecology?

TE ask a question to the class and a follow-up question to elaborate the initial question OTL

10 But why are you saying sustainable development?

TE ask for an additional elaborate meaning OTL

14 So, the question here would be how the population decreasing or increasing is and based on what?

TE asks preservice teachers what causes a population of the same species to decrease or increase. OTL

30 And then for random?

TE probes further for clarity of response. OTL

34 What do you understand by population density?

TE ask the class a follow-up question OTL

35 Yes …So, what is density?

TE repeats a question for the class to elaborate on the concept of population density. OTL

43 So, what are the kinds of things that you can draw from this population pyramid?

TE ask the class to give an interpretation of the population pyramid) OTL

44 What can you draw from the pyramid?

TE repeats the question for an elaborate response OTL

45 So, what can you draw from the population pyramid?

TE repeats the question to the class for emphasis to check students' understanding) OTL

46 Which cohort are you looking at?

TE ask the class a follow-up question for clarity) OTL

47 I mean which age group?

TE rephrases a question to the class for clarity OTL

Category 3: TE review the student's response and gives further explanation

11 So, if we talk specifically about the human population, we are looking at how resources are distributed.

TE reviews a student's response and further explains the concept. OTL

12 So, by knowing that Wits School of Education we have 3000 students…that is the population in this campus…so they know how they can distribute the computers and everything.

TE further clarifies that knowledge of population concept will help in resource distribution. OTL

36 So, it is per unit area at a given time and that is very important because when ecologists study a certain population, they look at that specific area.

TE reviews a student response and elaborates that population density is the number of individuals per unit area at a given time OTL

3.8.2 Analysis of interviews

I conducted semi-structured interviews with all participating teacher educators wanting to hear their views about their practice and the use of classroom talk as a learning tool. Focus group interviews were conducted with the pre-service teachers to explore their perceptions about classroom talk and group discussion on tasks the interviews were to help in answering questions one and two. Similarly, Creswell (2021) maintains that interviews provide detailed information on particular aspects; classroom talk in this case. An interview protocol was designed in light of my research question (see Appendix F). The interviews were audio-recorded, transcribed, and analysed for teacher educators' perspectives on their practice I used an inductive approach to make meaning out of the interview transcripts.

Hatch (2002) argues that some kinds of data are well understood when analyzed inductively. The inductive analysis means moving from the specific to general while spotting specific elements in the data and finding connections amongst them for generalizations. I started by listening and/or reading the interview transcripts repeatedly to get a sense of what was in the data. From the data, I identified frames of analysis which are segments of teacher utterances (Hatch, 2002). I then assigned codes to the segments which I thought are of importance to answer my research questions. These codes were assigned where teachers uttered words related to social interaction, mediation, and negotiating the meaning of concepts or engaging preservice teachers in interaction.

Mr Jonah: First, if I want my lectures to be interactive I often think of how I construct my slides sequence. Normally in biology what is important is relating structure and function. So what I do is I limit the text in the slides and I put the **structures of diagrams (Use of visuals)**. So let's say I am talking about the concept of ATP or let me just say a concept of a lung and I want to explain the function of the lung. I will put the structure of a lung **(Use of visuals)** and engage students with questioning **(Use of a question as a prompt**) asking them what do you see the structure looking like or what are some of the things they can see from the structure and they will tell me

3.8.3 Focus group discussions

I transcribed the audio-recorded focus group interview. To familiarise myself with the data generated I read through the interview transcript to understand how teaching activities help preservice teachers to learn science concepts. Having familiarised myself with the data, I coded the data. Coding the data was informed by my conceptual framework of the study. I sought occasions where preservice teachers discuss the activities or tasks they were engaged with. The interview transcripts were analysed both inductively and deductively. The deductive approach was informed by the conceptual perspectives that informed this study. To analyse the teacher transcripts and different interview transcript I focus on conversations between teacher educators and preservice teachers and the types of prompts and questions linking the interactions in science classroom. I sought occasions in the lectures where interaction between teacher educators and their preservice teacher provided an opportunity for engagement with life sciences content and discussion in the whole class or amongst peers. I extracted the codes from the first transcript and refined it for preservice teachers' perspectives about classroom activities they encounter in the course of lectures.

3.8.4 Document Analysis

In this study documents were PowerPoints slides from teacher educators lecture delivery. Document analysis is used to investigate if such documents provide opportunities for learning. Also how teacher educators employed the PowerPoint slides as visuals and how to engage the preservice teachers both cognitively and socially with PowerPoint slides. Analysis of documents is an important way of reviewing or presenting records-both written and electronic (electronic-based and Internet-based). Document analysis involves interpreting an artefact to gain meaning, gain insight, and improve knowledge of reality (Corbin & Strauss, 2008; Rapley, 2007). Texts can be books and photographs recorded without the influence of the researcher. For this purpose, evidence, such as cultural artefact, is not included. Atkinson et al. (1999) postulate that documents are "social reality facts", created, integrated, and used in structured social contexts (p. 47).

A document can be a kind of qualitative analysis of the time in which a document was taken by an investigator to present a voice and which refers to the topic of evaluation (Bowen, 2009). Document analysis analyzes the content of writing in themes almost similar to the focus of the discussion or the unit of analysis of the essay (Bowen, 2009). The rubric can be adapted to include papers. Examples accommodate student texts, mission statements, annual reports, policy brochures, textbooks, student essays, and syllabuses.

Document analysis is a very important analytical tool and is an integral part of many triangulation systems, a combination of research methods of the same thing (Bowen, 2009). To seek integration and optimization, qualitative researchers often use at least two resources using various sources and methods of data. The purpose of multiple data is to provide evidence that demonstrates credibility (Bowen, 2009). Findings across the entire set of information will reduce the impact of potential concern by examining the data collected by a completely different technique. In these study documents were slides of PowerPoint used as a mediational tool in teaching. Below I provided excerpts of educators' use of PowerPoint slides as tools for mediation in their lectures.

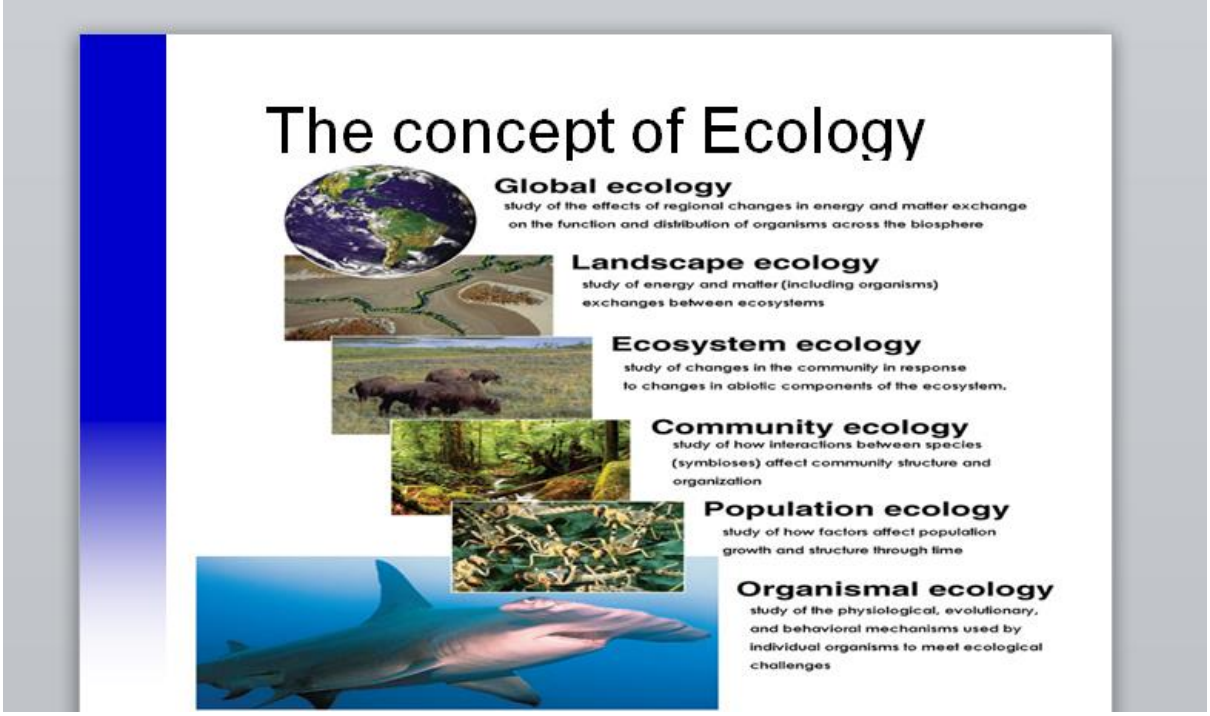


Figure 3.1 A slide illustrating ecology concept

3.9 Rigour in the study

3.9.1 Validity and reliability

Rigour and reliability are also of importance to qualitative research. Rigour has been used to describe qualitative research-related qualities. Morse, Barrett, Mayan, Olson, and Spiers (2002), posited that research is worthless without rigour, it becomes fiction and loses its usage. Further, the authors described rigour as the strength of the research design and the suitability of the method to answer the questions. Davies and Dodd (2002) refer to the rigour of study reliability and validity, and that the definition is a quantitative bias inherent in the conception. It is of paramount importance in qualitative research that data should be studied prospectively and ensures that the interpretation is reliable, transferable, and confirmable. This study adopted Lincoln and Guba's (1985) four ways to gain credibility in qualitative research.

3.9.2 Credibility

This is concerned with the internal validity of the qualitative data. Lincoln and Guba (1985) pointed out that ensuring credibility is one of the most important factors in establishing the credibility of an appropriate investigation. It is hopeful in the 'truth' of the findings. Credibility is established when the findings of the research are confirmed and accepted by

the research participants because they are very critical in judging the credibility of the overall research findings. I employed different instruments to collect data, classroom observations, semi-structured face-to-face interviews and focus group interviews. Each of these methods provided me with rich data for analysis. I compared the data obtained with each method and corroborated it against the other methods. There were differences and similarities in the data obtained with the different methods, which is one way of increasing the credibility of research findings.

3.9.3 Transferability

Merriam (1995) suggested (as cited by Shenton, 2004), transferability is a concept of validation of qualitative research, which is the ability of the findings of a particular study to be applied to a different context (p. 69). It is achieved by providing an in-depth account of the research procedure to allow a reader to see if the results can be transferred to a different setting. To ensure the transferability of the research findings, I provided a detailed process of the data collection procedures concerning the theoretical frameworks of the study.

3.9.4 Dependability

This is concerned with the reliability of the study. Marshall and Rossman (2014) noted that the varying context of the problem examined by researchers conducting qualitative studies renders the reliability of the research quite problematic. This is because most qualitative studies are conducted with human subjects, and humans are dynamic, which affects the phenomenon under investigation. Shenton (2004) suggested that dependability "may be achieved through the use of overlapping methods such as focused groups and individual interviews" (p. 71). The overlapping methods may be similar or dissimilar but must complement each other towards obtaining data.

To make the research findings dependable and trustworthy, I employed more than one tool to generate data for the study. I employed classroom observations, individual direct interviews, and focus group conversations to generate data from the university. I also gave a detailed description of the methods that I used to arrive at the findings. I deliberately did so to provide readers with the opportunity to have an in-depth understanding of the effectiveness of the methods employed concerning the research paradigm and theories.

3.9.5 Confirmability

Confirmability is about objectivity in research. Research is confirmable when the investigator's bias is reduced to a minimal level or even eliminated. When findings are not

influenced by the researcher's motivation or interest then the confirmability of the study is established (Ang et al., 2016). This can be achieved by placing greater emphasis on the triangulation of the methods or techniques for data collection. Even though case studies may not be free of researchers' bias (Harris, 2011), I applied appropriate measures such as neutrality during my interaction with the participants. I maintained neutrality as much as possible throughout the conduct of the research, which helped me to mitigate my personal beliefs, and prejudices in the conducting, analysis, and reporting of these findings. I also ensured confirmability in this study by making an in-depth methodological description to let the reliability of the study findings be validated. I compared and contrasted the research findings from individual and focus group interviews with the reviewed literature and the theoretical frameworks guiding the study. I drew conclusions based on the interwoven discussion of findings.

3.10 Ethical considerations

Ethical considerations are central to academic investigations and scholars should guarantee that investigation is conducted ethically (Basset, 2014). Basset (2014) goes on to say that researchers should make their decisions based on ethical considerations and this should be kept in mind at all stages of the study, namely design, obtaining sample access, collecting and analyzing data, compiling reports and disseminating research findings (Basset 2014, p. 56).

Strydom (2013a) defines ethics as,

> "a set of moral principles which is suggested by an individual or group, is subsequently widely accepted, and which offers rules and behavioral expectations about the most correct conduct towards experimental subjects and respondents, employers, sponsors, other researchers, assistants and students" (p. 114).

Strydom (2002) and Cooper et al. (2006) posited that the essence of ethics is to certify that no participant is harmed or undergoes any painful experience. This was affirmed by Leedy and Ormrod (2005) who argued that participants in a study need to be informed and be willing I explain that if at any time participants feel uncomfortable or no longer feel like participating they will be free to stop participating.

All participants were informed and gave consent knowing that their participation in the study was voluntary and others students not willing were released from the study with no fear of any consequences from the researcher.

Pseudonyms were used in all writing or presentation in which the data is used. I assured the participants that the responses will be kept confidential and that confidentiality will be maintained throughout the study.

Not disclosing or discussing information provided by an individual with others. Audio recordings were kept under lock and key in my supervisor's office at the university for 3-5 years and thereafter shall be destroyed.

The data generated during research was used for my study and may be shared only on academic platforms using pseudonyms. I deleted the identifier anonymously and verified that something omitted from the data did not change the findings' original meaning (Creswell, 2014).

Written permission was sought from the Head of School of Education to grant me access to generate data in the School of Education and permission was approved (See Appendix B and C).

I negotiated for access from teacher educators that were teaching year three pre-service teachers and they allowed me access to observe their lectures.

3.11 Chapter summary

This chapter introduces the design of research approaches and methods for conducting this research. I begin with a discussion of case-based research followed by a brief discussion of case study design and research. I introduce the participants of the study and methods used to generate the data and data analysis and, I conclude with ethical considerations. In the next chapter four, I discuss data analysis and presentation of results.

CHAPTER FOUR: DATA ANALYSIS AND PRESENTATION OF FINDINGS

4.1 Introduction

The focus of my study was to investigate how teacher educators create opportunities for learning life sciences with a large population of preservice teachers. To do that these are the research questions that guided the study.

How do biology teacher educators create opportunities to learn life sciences?

1. How do biology teacher educators facilitate the creation of opportunities in their lectures?

2. What is the nature of pre-service teachers' engagement with opportunities provided by educators?

3. What evidence of pre-service teacher learning can be gleaned from their engagement with learning opportunities in lecture setting?

To answer these research questions, I collected these forms of data, audio recordings of lectures, interviews, and documents (artefacts). The audio recordings of lectures and interviews were later transcribed into transcripts as text. I then proceed to analyse the generated data to answer my study questions. According to Henning and Van Rensburg (2004), data analysis is the process of examining and understanding raw data to answer the research questions. Therefore, data analysis involves the search for explanation and understanding that leads to the advancement, evaluation, and development of concepts and models (Bosman, 2015).

4.2 The analysis of teaching transcripts

I audio-recorded all the lectures I observed from the lectures of the four teacher educators I observed. This was to help me provide evidence for the study. The analysis of data was done in the step that I describe below.

Step one

I transferred the audio recording to my personal computer and an external hard drive as a backup. I transcribed the audio-recorded interview while I employed a transcriber to assist me with part of my data transcription. The transcription was done verbatim.

Step two

To familiarise myself with the data generated I read through the teaching transcript to understand how teacher educators create opportunities for preservice teachers to learn (Attride-Stirling, 2001). I read the transcript three times to help me make sense of the data. The familiarization work in this step allows researchers to start formulating questions, taking notes about potential data items of interest, and making connections between data items. The coding process for step three.

Step three

Having familiarised myself with the data I coded the data. Coding the data was informed by my conceptual framework of the study. I sought occasions in the lectures where interaction between teacher educators and their preservice teacher provided an opportunity for engagement with life sciences content and discussion in the whole class or amongst peers. The codes are generated in this phase, not themes. According to Boyatzis (1998), a code is the most basic element of raw data suitable for valuation within the context of the phenomenon (p. 63). A code should be sufficiently well-defined and demarcated such that it does not overlap with other codes (King, 2004; Nowell et al., 2017). Suitable codes were accompanied by a section of text that provides context for the extract (Braun & Clarke, 2006). The initial codes yielded sixty-three codes. Below is an example of a coded excerpt from one of the teacher educators Dr Jonah.

1 [1]L: Now from Friday, what did we say is the key principle about biology topic was something that kept going back to as one of the key things you need to remember about biology and biological processes remember? I heard yes. Anyone remember? Anyone wants to guess?! TE introduces concepts of cellular respiration without providing answers

S: Structure and function

7 Any other contributions? (TE ask for additional rejoinder

8 How do you differentiate it from community ecology? TE ask for additional response

9 <u>But why do we study population ecology or ecology? Or, why do ecologists study ecology or population ecology?</u> TE ask a question to the class and a follow-up question. OTL

[1] Numbers indicate turns during interaction.

10 …But why are you saying sustainable development? TE ask a follow up question OTL

11 So, if we talk specifically about the human population, we are looking at how resources are distributed. TE ask a question to the class and a follow-up question. OTL

12 So, by knowing that Wits School of Education we have 3000 students…that is the population in this campus…so they know how they can distribute the computers and everything. TE further clarifies that knowledge of population concept through an example. OTL

13 I told you that I will show you the levels of ecology. So, it ranges from organismal ecology to global ecology. With the organism, we are looking at how the organism responds to temperature exchange. So, it is about the behaviour and physiological features of that organism. TE further explains the levels of ecology using a PPts slide OTL

14 So, the question here would be how the population decreasing or increasing is and based on what? TE asks a question OTL

15 Those we call the levels of ecology but the focus is now on population ecology. So, we have said that ecology is the study of organisms relate to one another and their environment and populations are organisms of the same species that live together at the same time TE uses PPT slides to illustrate a concept. OTL

Step four

After having coded and collated the data, the researcher examines the extracted extracts and reads thoroughly seeking potential similarities for grouping further broader meaning. The process led the researcher to refine and collapse initial codes into categories of seven broad themes. The seven broad categories are shown below.

Category 1- TE introduces concepts with questions without providing answers

Category 2- TE probes preservice teachers for elaborate meaning for clarity

Category 3- TE review the student's response and gives further explanation

Category 4- TE uses PPts slides to illustrate a concept.

Category 5- TE explains verbally only

Category 6- TE uses illustrations on the board

Category 7- TE employs preservice teachers with mind-engaging activities

Braun and Clark (2012) provide an analogy in which individual codes would be bricks whereas categories would be walls. A fundamental element of category identification is the

active and explanatory nature of how those walls and roofs are constructed. To build categories, a researcher needs to analyse, combine, and compare, how codes relate to each other (Varpio, et al., 2017b) categories are constructed by the researcher. I proceed to analyse both deductively and inductively three remaining educators teaching transcripts using the initial seven broad categories. The analysis was inductive in the sense that I was open to new codes that may emerge from the remaining teaching transcripts of the three educators. Eighteen categories emerge altogether for all the four educators observed. Re-reading and revising codes and categories are expected parts of the analytic process. As part of the process of my validation, I gave two of my colleagues who have graduated the transcript to code to establish an agreement with my coded transcripts. In theory, this iterative process could continue indefinitely; nevertheless, King (2004) and Braun and Clarke (2006) suggested stopping once all items that appear relevant to the study question are included in the coding process, categories have been reorganized, and additional modifications are not yielding substantial changes. Below are categories that emerge from the initial codes of data of the study.

4.3 Results from the analysis of teaching transcripts

Categories that emerged from the analysis of the teaching transcript

Eighteen categories emerge from data analysis of the four teacher educators observed, the categories are provided below.

Category 1:	TE introduces concepts with questions without providing answers
Category 2:	TE probes preservice teachers for elaborate meaning for clarity
Category 3:	TE review the student's response and gives further explanation
Category 4:	TE uses PPts slides to illustrate a concept.
Category 5:	TE explains verbally only
Category 6:	TE uses illustrations on the board
Category 7:	TE employs preservice teachers with mind-engaging activities
Category 8:	TE introduces concepts with questions without providing answers to repeated questions without answering
Category 9:	TE uses a video clip to introduce a concept
Category 10:	TE uses verbal explanation only to introduce a concept
Category 11:	TE introduces concepts creating a scenario

Category 12: TE uses slides to review previous lectures to engage the mind of her students with

Category 13: TE uses PPts slides to probe for elaborate explanation

Category 14: TE introduces concepts with explanations and questions without providing answers

Category 15: TE probes to check preservice teachers' understanding

Category 16: TE verbally explains concepts after repeated questioning the class without a response

Category 17: TE introduces concepts with questions without providing answers and uses PPts illustrations

Category18: TE review the student's response and gives further explanation and probes further

4.3.2 Presentation of categories that manifested across the four educators observed

Of the eighteen categories listed above, four of them namely categories 1-4, were observed across all four teacher educators. I present and discuss these categories next.

4.4 The occurrence of opportunities across the four educators observed

Category 1: TE introduces concepts with questions without providing answers

This category manifested across all four cases. Teacher educators were observed deliberately opening spaces for interaction by asking questions but not providing answers. This is an effort by the teacher educators to stimulate the preservice teacher to engage their minds to respond to the solicitation for their views about the topic of discussion in class. However, in contrast to asking questions, Dr Lydia for this category asks a repeated question without providing answers to engage the minds of preservice teachers. This finding confirms the suggestion of (Johnson & Golombek, 2016) that preservice teachers need the invitation to be active participants in the social space of learning. Asking questions pausing for answers also is a platform for educators to solicit the responses of preservice teachers and to work with their prior understanding (Vacca, 2013).

Preservice teachers responded to initiation in form of a question with few students responding. This leads to teacher educators probing and rephrasing initial questions. The question achieves minimal interaction especially if the questions are close-ended. For this category in the case of Dr Lydia when preservice teachers are not responding, she often rephrases the questioning an effort to position preservice teachers to respond to her solicitation. Similarly, Dr Lydia and

Dr Charles will instruct students to discuss with their peers, while, Ms. Rose will just explain the concept after a pause without a response from preservice teachers. And finally, Mr Jonah will use a visual representation from his PowerPoint slide to explain the question. This affirms the submission by (Bansal, 2018) that classroom teacher questioning supports. This means that the type of questions used by teacher educators could improve the quality of dialogic interaction. Hence, teacher educators should employ open-ended questions to deepen the quality of interaction in lectures. Below is an excerpt provided for the first category.

L: Is a nice topic of discussion right? Here are some terms concerning energy transfer. We throw them around all time and sometimes we confuse them and we need to tease them apart so that we can be able to proceed. We've taking respiration, respiration, and am sure you saw from the short quiz you have been mugged in as to the actual processes of respiration and what happened. Which is respiration and which isn't? Is breathing in and out respiration? Is it only about what happens in the cell? When respiration does start and when does it end? When does it relate to photosynthesis?

Category 2: TE probes preservice teachers for elaborate meaning for clarity

This category manifested across the four educators observed to generate data. However, in contrast to Ms Rose and Dr Jonah, Dr Lydia and Dr Charles give an extended time for the probing questions to be responded to by preservice teachers. The extended wait time gives preservice teachers time to provide their contribution to the meaningful negotiation process. This finding manifested across the four educators observed to generate data. Giving preservice teachers extended time of probing opens opportunity for whole class interaction and deepens the interaction and hence, engagement for learning with the content of discussion in the social space. Probing for clarity by the educators was employed when responses were not provided by the preservice teacher or when the elaborate response to an invitation is needed for clarification.

L: What does the ana stand for there? Ana stands for something Ana stands for putting together or building up**.** What kinds of processes will this be then? What do you think the processes will be? The ana processes We just said ana is about building up, even going to the higher-order thinking as synthesizing, where would you place the photosynthetic processes that you just see there? Is there something being built-up? Can you identify the things you are putting together? Identify the product. That is where

your anabolic processes will come in and almost the flip side of it is the catabolic processes. The catabolic processes what do you think are happening there? I hear somebody said it.

This finding points to the need to engage the preservice teachers in the process of knowledge building by creating opportunities for classroom interaction (Lemke 1990; Kubanyiova, 2012). The communicative strategies used by biology teacher educators to open spaces for conversation that provides opportunities for preservice teachers' active interaction in a lecture setting are influenced by their perspectives on teaching with a large student population (Walsh, 2006). These active interactions are good for deeper engagement in learning.

Category 3 TE review student's response and gives further explanation

This theme was seen across the biology teacher educators teaching transcript. However, Ms. Rose normally pauses in the course of reviewing preservice teacher's response and also she evaluates before reviewing preservice teachers' responses. Dr Lydia will instruct preservice to 'keep it in mind' as it will be revisited to form coherence in the process of review of responses. The excerpt is provided below.

L: So, what will be the difference between aerobic and anaerobic respiratory processes? Yes, I heard it, somebody said something here. Yes, say it out load you are saying the right thing. Anyone want to try? Yes, sir

S: Aerobic respiration depends on the availability of oxygen to occur whereas anaerobic respiration does not necessarily need oxygen

L: Okay. And cellular respiration comprises both these processes. We are calling them catabolic pathways. Catabolic pathways. What did we compare catabolic pathways to last week? Anyone remembers? Not even whispering? We compared them with anabolic processes remember? And we said anabolic processes are what kind of processes? I Hear some whispering, louder yes Ma'am. Sorry in anabolic processes we are building or putting together substances to produce new substances yeah.

A review of preservice teachers' responses by teacher educators is to help in mediating their learning. As further explanation helps provide clarity. Educator Mr Jonah and Dr Charles both review preservice teachers' responses and provide further explanations. The excerpt is given below.

L: What kind of thinking do they do? TE probes further for class response

S4: Metacognition

L: Metacognition. Repeating. The ability to think ahead and the ability to reason TE reviews preservice teachers' response for clarity

L: So the first question is define biotic potential of a population. Anybody? When we talk about biotic potential, what are we actually talking about? Okay…yes mam?

S11: It is the number of resources that a population can use to reach its maximum growth.

L: Okay, put in another way? Leslie? You even came late…

S12: Sir, I said this is the rate at which a population a specific species can increase without any limiting factors

L: So, if there are no limiting factors, it means that the resources are abundant then it goes back to her definition. Next question explains why populations grow slowly as they reach their carrying capacity. I should be looking for those ones in lab coats.

(Students laugh)

L: Okay, who wants to answer?

S5: I am thinking that there would be slow growth due to high limiting factors? So, with the high limiting factors…like interactions like completion, we have outputs that organisms will either migrate or die or something like that…I was trying I was not

The essence of reviewing with further explanation is to solidify preservice teachers emerging understanding as educators mediate the learning process (Vygotsky, 1978).

This finding points to the need for a more knowledgeable other to mediate the process of appropriation of new information (Vygotsky, 1978). Mr Jonah and Dr Charles used students' contributions as resources in the meaning negotiation process by reviewing students' contributions and giving additional explanations to buttress students' contributions.

Category 4-Teacher educators use PowerPoint slides to illustrate a concept.

This finding manifested across the four educators observed to generate data. However, educators vary in the use of this mediational tool to engage with preservice teachers in the interactional space in creating opportunities to learn. Ms. Rose uses the content of her PowerPoint slides to engage her preservice teachers with questions and visuals and also to explain the concept. Dr Jonah limits the text in the slides and puts the structures of diagrams. He uses the text to engage preservice teachers with probes as they voice their understanding of the topic of discussion. Dr Lydia uses her PowerPoint slides to review the units of her lectures. The use of PowerPoint slides to review a lecture unit by Dr Lydia as shown in the slide below promotes cognitive interaction for her students. Students are shown a visual of

three instances of Adenosine triphosphate helping in mechanical work in Chlamydomonas through the use of flagellum. And active transport of materials across the membrane and the third being enzymatic activity on the conversion of substrate to product. Students engage in both visual and summary of the text in the review of the content taught.

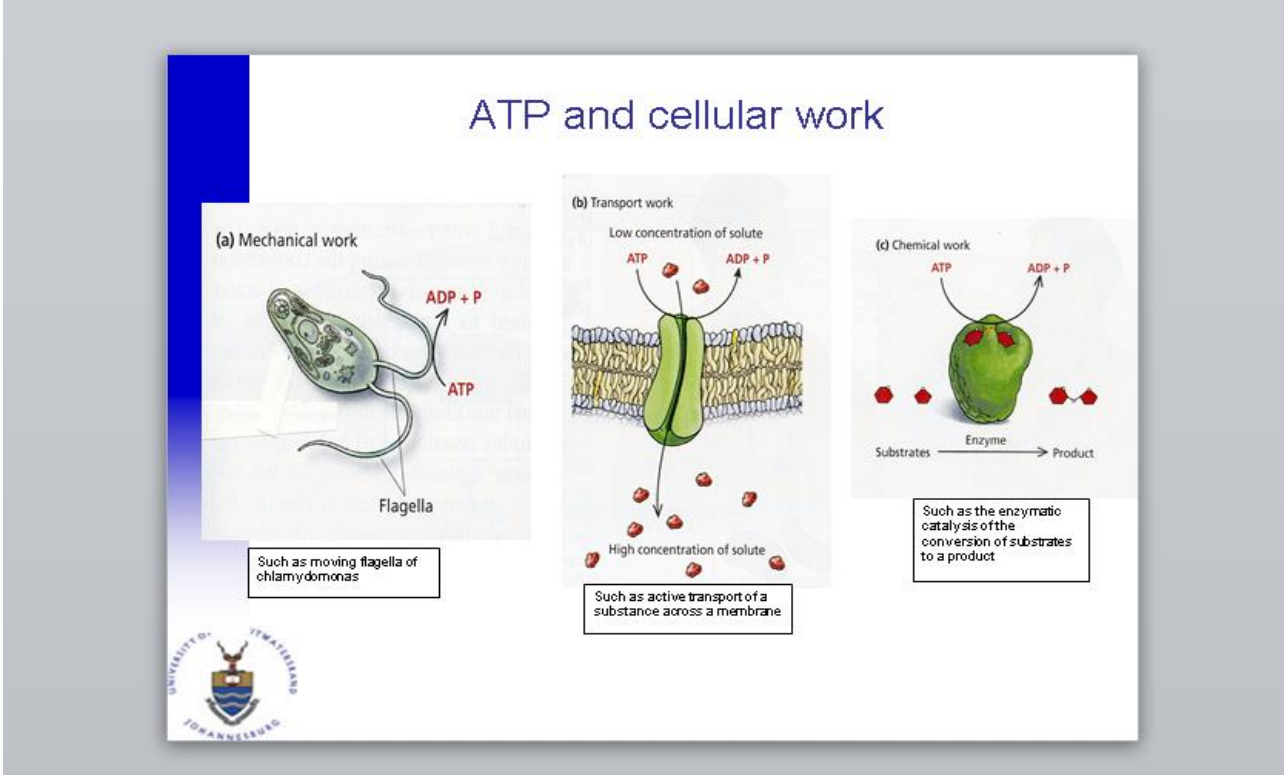


Figure 4.1 A slide illustrating ATP and cellular work

Dr Charles uses his PowerPoint slides to model the analysis of environmental issues and their connection and how they affect human well-being. Dr Charles, similarly also employs lecture PowerPoint slides to model the interaction of the bio-physical world to model the happening in our environment. The summary of the slides assists the student to view the complex interaction that affect our environment over time. This facilities cognitive interaction with the content being taught. Dr Charles PowerPoint slide is provided below. The use of PowerPoint slides creates opportunities to both visualise and engage with the content of lectures as platforms to learn science concepts.

The Environment:
The interactions between the bio-physical world, and the social, political and economic forces that organise us in this world. Environmental concerns, risks and issues emerge from the interactions between the bio-physical world and the social, economic and political forces which organise us in the world.

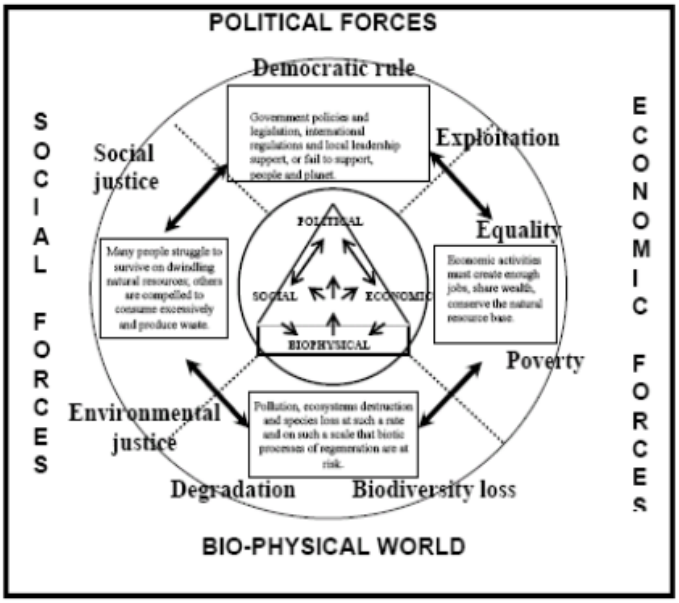


Figure 2: Diagram representing the aspects of the environment from O'Donoghue (2001)

Figure 4.2 A slide illustrating interactions between bio-physical world social and economic

Even though all educators employ PowerPoint slides in their lecture delivery usage varies in their design. The three educators designed the varying spread of text diagrams and probing questions to engage their preservice teachers. The use of PowerPoint slides in lectures according to (Arneson & Offerdahl, 2018) to allows biology students to navigate complex biological visualizations with a large student population. The essence of the use of PowerPoint slides by educators is to provide mediational tools to support the process of learning. Hence PowerPoint slides are an instructional tool that supports learning. These four categories discussed above are areas of commonalities for the categories of opportunities in teaching transcripts analysed for the four educators. The four categories discussed above are the ones that manifested in all four teacher educators' teaching. However, as can be seen above, although all four categories were utilised by the teacher educators, there were differences in the way they used them. This resulted in differences in the quality of the engagement and hence the quality of the opportunities for learning that were created. In the next section, I present the rest of the categories, indicating who used these categories in their teaching and how.

Category 5-TE explains verbally only

This finding is not common across the teaching transcripts of the educators. It manifested in Mr Jonah and Dr Charles's teaching transcripts. The use of verbal explanation was a non-

interactive approach. The preservice teachers listen to the teacher educators' explanation of the scientific story of the content taught. This agrees with what (Mortimer & Scott, 2003) argues that there should be a balance between dialogue and communicative approaches for science learning to take place. However, the educators establish their authority as they build the scientific story in the course of their lectures. This finding points to the need for educators to explain concepts to bring clarity to the class (Aranda et al., 2020). Educators explaining phenomena are a practice that helps to develop understanding this agrees with the new vision for science education classrooms (NRC, 2015). To teach preservice teachers with different levels of content knowledge is challenging.

Category 6-TE uses illustrations on board

This finding manifested only in Mr Jonah's teaching. The use of illustration on the board allows Mr Jonah to vary his pace of lecture delivery as preservice teachers need time to assimilate new information. This allows Mr Jonah to regulate the content to give his preservice teachers and also adjust his lecture delivery. The board could serve as a platform where preservice teachers could visualise the educator's mind. This finding points to the relevance of the board to manage a large population of students with illustrations on the board. Mr Jonah reviews his lecture ideas by using chalkboard illustrations and offers students platform to ask questions from the content taught to students. The use of chalkboard to enhance his teaching provides channels of whole class discussion hence, creating opportunity to learning.

Category 7-TE employs mind engaging activities with preservice teachers

This finding is visible in three educators teaching: Mr Jonah, Dr Lydia, and Dr Charles. Mr Jonah used diagrams on his PowerPoint slides to engage the mind of his preservice teachers in a collective activity with questions that will demand preservice teachers to think together to provide solutions to the instructional activity. "So think about why individuals in a population would be clumped, random, and uniformly spaced. So, I am giving you 5 minutes at most…absolute silence, I want you to think of the question and write down your thoughts". This is one activity provided for the whole class to engage their mind with. After five minutes Mr Jonah provided additional work to guide his students.

Dr Lydia engaged her preservice teachers in a peer discussion with mind-engaging activity this allows for peer mediation in the learning process as they interact on the social plane of the science classroom. "Which one is the adenosine in the picture on the board okay?

Adenosine, adenine and ribose okay together they make the adenosine part of the ATP molecule. Yeah and the yellow blocks, what are the yellow blocks? Speak to the person next to you if you can see the difference (peer Discussion) okay so what did you pick up?" This is the mind engaging activity provided by Dr Lydia and Mr Jonah employs a range of activities to engage the minds of preservice teachers. These activities are questions to respond to, video clips to watch and discuss, and finally visual prompts from his PowerPoint. Engaging in activities that place a demand on preservice teachers' cognitive ability is necessary for preservice teachers to be exposed to productive struggle and sense-making of concepts.

Category 8 -TE introduces concepts with questions without providing answers to repeated questions without answering. This is similar to categories but the difference is that the questioning of students' is repeated at a stretch. This finding is unique to Dr Lydia's teaching transcript. Questioning is a resource for teaching and hence learning with a large population of students. Repeated questioning during her teaching without providing an answer to open up interaction, provide an opportunity for participation, and for the educator to check her students' previous understanding. Dr Lydia's questions demand preservice teachers to think- Which is respiration and which isn't? Is breathing in and out respiration? Is it only about what happens in the cell? When respiration does start and when does it end? When does it relate to photosynthesis? This repeated questioning was how she introduced the topic of respiration. This repeated questioning is a strategy to facilitate social interaction (social interaction in lectures usually is initiated by teacher educators' solicitation which is followed by a response from a student) which is necessary for learning to happen. The pedagogical aim of repeated questioning without providing an answer is to draw preservice teachers to provide responses that might reveal their misconception or correct knowledge of the topic of discussion. Repeated questioning without providing answers is an invitation to share ideas in a joint activity (Johnson & Golombek, 2016). Clarity, sequencing, and delivery of questions are important to facilitate students understanding of the discussion and thus lead to a quality engagement for learning.

Category 9- TE uses a video clip to introduce a concept

This finding is only manifested in Dr Charles's teaching transcripts. Employing a video-clip called "Anthropocene" to introduce a concept engages the mind of students and the visual knowledge may be enhanced. The video presents a uniquely effective means of illustration of complex sets of classroom encounters that may be resistant to verbal representation and which

in any event may be more clearly and powerfully demonstrated by real people in real situations than they may be by the abstraction of a teacher educator. Dr Charles selected an "Anthropocene" video clip for his students to watch for four minutes. After this he instructed the students to discuss with their peers. Even though the video clip presents an effective means of illustration, the time given to digest the information was limited. Hence, limited interaction ensued among students. Newton and Sorensen (2010) highlighted the capacity of video materials to: exemplify and share good practice" in addition the study by (Mitchell, 2010) supports how video clips can be used to model practice to preservice teachers. Video again lends itself to instructional activity because of how it can capture the 'real' and the complex encounters in classrooms (Marsh, & Mitchell, 2014). This finding is a pointer to the need for diversifying instructional approaches to facilitate engagement in the learning process.

Category 10-TE uses verbal explanation only to introduce a concept

The finding manifested uniquely with Dr Charles's teaching transcript. Employing explanation to introduce a concept the educator takes an authoritative stance to his lecture orchestration. He presents the scientific view without soliciting preservice teachers' ideas. An explanation could serve as a "scaffold" to help the preservice teacher to transition to an emergent understanding of concepts they encounter in the social plane. Hence the explanation of concepts verbally is relevant to the process of teaching and learning. Verbal explanation supports fruitful discussion because teacher educator by explanation brings the visibility to the content of teaching to the student.

Category 11-TE introduces concepts creating scenario

This finding uniquely manifested in teaching. Dr Charles' created scenarios of blood test and unequal distribution of resources as stories to introduce concepts. This deliberate strategy is to stimulate the imagination of preservice teachers to think creatively about the content they are exposed to. The essence of content delivery with scenarios as narrative stories is to engage the minds of preservice teachers providing a platform for discussions and interactions. The scenarios are given below:

> One day I didn't see well and then I went to a doctor and they did blood test, they found that my blood has too much cholesterol and that was possibly because of my age. My doctor said ah young man there is tendencies for obesity.
>
> Inequitable distribution of resources you go to one part of the town you are walking under trees and you go to another part of the town only one street even bigger vehicle cannot move. There are no trees and the houses are the cheapest and you have the

largest concentration of people in that place. If you look just across the street you will see 18-20 roofed houses and is probably just the husband and the wife with grown children, they only have one or two. And what does that mean in terms resources.

The use of scenarios to introduce concepts is a good teaching approach. Preservice teachers are engaged cognitively with content. Preservice teachers develop images in their minds about the scenario these are vital to the content they are exposed to (Zabel & Gropengiesser, 2015). The preservice teacher listening to the scenarios will engage cognitively and hence facilitate the process of learning.

Category 12-TE uses slides to review previous lectures to engage the mind of her students

This finding is unique to Dr Lydia's teaching transcripts. The use of PowerPoint slides to review lectures.

L: So keep it in mind we come back to it. Here is some of what we said on Friday we've looked at photosynthesis and we've moved on to respiration and we distinguish between cellular respiration and gaseous exchange. And looked at how they served different functions related but different function. And often confused or used interchangeably and what we are looking at here is cellular respiration right and we also said of course we want to pay attention to linking structure and function alright and then we looked at exactly what topics we are going to cover you got this on your slides if you noticed I just blocked some sections in red things that you are going to cover but somebody came to me and said wait a minute we are not going to be here on Friday did you remember?

David Ausubel's research has shown the importance of advanced organizers (AOs) in students' rapid learning and retention abilities (Ausubel, 1977), which are common learning requirements in undergraduate biology classroom settings. At the intersection of previously acquired knowledge structures and new information, new and meaningful learning occurs. Two conditions must be met for appropriate AO use: (a) students must process and comprehend the information presented in the AO, and (b) the educator must clearly indicate the relationships between the AO's basic concepts. These ideas supplement calls for increased visual literacy among biology students (Arneson & Offerdahl, 2018). Historically, PowerPoint slides have been used to provide an overall structure to the instructional episode, and each individual slide can be viewed as a mini AO within the context of the larger lesson (Ausubel, 1978). Hence, Dr Lydia's uses of PowerPoint slides to review lectures. Each individual slide can be viewed as a mini AO of the entire instructional content to teach. The review of Dr Lydia's teaching forms a link in the sequencing of her teaching and it helps to build links between units of content to be taught and the slides serve as a mini advance

organizer for preservice teacher learning (Ausubel, 1977). This finding also points to the need for coherence in sequencing lecture design. The use of PowerPoint slides compliments the need for visual knowledge of biology students (Arneson & Offerdahl, 2018). The use of text and diagrams on PowerPoint slides engages students with different learning styles. However, the design of the PowerPoint slides is used to capture and arouse students' interest and provides a learning opportunity.

Category 13-TE uses PowerPoints slides to probe for elaborate explanation

The use of PowerPoint slides to probe is unique to Dr Lydia's teaching transcripts.

L: What did we say is the energy currency for human organism**?** I heard it.

L: Yes, thank you. And what is ATP? We spoke about all of this and we came to ATP. And we said a few important things about ATP the molecule okay. First of all, we said the ATP is an acronym for what?

S: Adenosine triphosphate

L: Meaning? Is the adenosine? We spoke about the adenosine and we even related it to another topic that we covered in biology. Which one is the topic?

L: Which one is the adenosine in the picture on the board okay? Which one is the adenosine…. adenine and ribose okay together they make the adenosine part of the ATP molecule. Yeah and the yellow blocks, what are the yellow blocks?

L: Yes I heard it

S: Phosphate?

The PowerPoint slides to probe for elaborate explanation create an opportunity for Dr Lydia to engage preservice teachers cognitively with the content taught and the preservice teachers also visualise the activity in the course lecture delivery. This finding points to the need for educators to develop a pedagogical practice of promoting sense-making by probing questions in the course of lecture delivery. The need for instructional improvement for mediating the learning of preservice teachers is also facilitated by the use of PowerPoint slides as a tool (Tekkumru-Kisa et al., 2015). Also, an important aspect of biology teaching is to incorporate a visual representation of phenomena to facilitate clarity for students' process of meaning-making. The use of PowerPoint slides provides a platform for students to engage in mental activity and refine their prior understanding.

Category 14-TE introduces concepts with explanations and questions without providing answers. This finding is visible only in Ms. Rose's teaching transcripts. The use of explanation

to introduce the concept and then engage her students in sessions of the question without providing an answer is an innovative procedure of employing explanation to reduce the cognitive demand of the content the educator was enacting to her student. And she followed with questioning without providing answers, the solicitation of responses from the student population. Few students responded when Ms. Rose rephrased the questions for students to contribute to the teaching of content. The process allows students to think through the explanation now that the demand of responding has been modified by explanations to get the student population to respond. This affirms the argument by Abdulhamid and Venkat (2018) that explanation could be used in the whole class to ease the cognitive demand and shift preservice teachers towards sense-making engagement with the content of the discussion.

Category 15-TE probes to check preservice teachers' understanding

L: As it's moving, what about it? What about those things?

S: Because it's, I think it 'B is passing through the bilayer

L: Right. Mm she managed to tell us what happens to those different kinds of molecules that have got to pass through uh that bilayer of protein, the bilayer of lipid. And who can explain what happens at D? What happens at D? Yes, ah, yes tell us what happens at D? Yes hear, mmm, Is that process clear - the function of plasma membranes? Yes? Are you discussing or do you have a question?

The finding is unique to educator Rose's teaching transcript, probing students to ensure that they are in tune with you in the course of your content delivery or that their silence means they are engaging with the content differently is very important. Inviting students' contribution promotes interaction that paves way for their concept learning. The productive engagement triggered by the teacher-educator probes to preservice teacher contribution provides opportunities for learning (Abdulhamid & Venkat, 2018). However, for these probes to transition to learning of preservice teachers their responses need to reveal a new understanding.

Category 16-TE verbally explains concepts after repeated questioning the class without a response

The finding manifested in educator Ms Rose's teaching transcript. The educator after repeated questioning provides a verbal explanation. This is an effort to dispel the ambiguity of the

content to the students by being responsive to their silence of not contributing to the educator's solicitation. She employed a series of probes to encourage preservice teachers to engage with the content in her lecture. Azevedo and Sherin (2012) posit that students' deeper engagement with the science concept is a requirement for learning to take place. For students to engage with the content of lecture delivery is the premise of the quality of interaction facilitated by the teacher educator. Ms Rose's verbal explanation after repeated questioning of her students is an instructional move to get the class to contribute to the meaning-making process.

Category 17-TE introduces concepts with questions without providing answers and uses PowerPoint slides illustrations

This finding is unique to Rose's teaching transcript; she introduces concepts with questions without providing answers and uses PowerPoint slide illustrations. The use of both probing questions and PowerPoint slide illustrations is an important teaching procedure. The teaching procedure provides an opportunity for learning by using probing questions and visual PowerPoint slides. The teaching procedure supports the mediation of students with content by both questions and PowerPoint slides. This is in agreement with the vision of the new science education reforms (NRC, 2012). Van de Pol et al. (2010) posit that to scaffold the learning of Students to achieve the desired outcome, the use of tools (artefacts) is necessary. Hence, this finding points to the need to scaffold the learning process with a productive procedure to facilitate learning with a large student population. The teaching opportunities were probing questions and PowerPoint slides illustrations to facilitate learning.

Category 18- TE reviews the student's response and gives further explanation and probes further

This finding manifested in Ms Rose's teaching transcript, which means that educator Ms Rose engages her students with probes after reviewing their contribution in the process of discussion. Further probing after an explanation provides the students with an opportunity to engage deeper with the content of the discussion. This type of discussion in a whole class interaction builds the process of meaning-making of the concept being taught (Scott et al., 2006). The review of responses with further probing from the educator is to nudge the students to new understanding within the zone of proximal development (ZPD).

These are the different opportunities provided by the educators observed for this study. However, learning opportunities do not translate to learning until deep engagement is

facilitated by the type of interactional probes and questioning or explanation provided by educators in their lectures.

Table 4.1 below shows the summary of lectures observed for data generation.

	Lesson	Number of students who talked	Number of student utterances	Number of lecturer utterances
L Jonah	Characteristics of populations	11	40	70
	Models of population growth	13	67	86
	Density-dependent and density-independent factors affect the population size	07	50	67
	Interactions in the environment	10	25	41
	Human population growth	09	34	40
L Charles	Introduction To Environmental Studies	10	18	42
	The state of the planet today	02	02	33
L Lydia	Biochemistry of Respiration	05	15	35
	Anaerobic Respiration	08	20	39
	aerobic Respiration	04	05	22
L Rose	Introduction to cells	07	13	27
	Cell organelles	15	41	95
	Cell structure and function	11	22	46
	Mitosis cell division	21	73	98
	Mitosis review	26	70	76

All lectures for the four educators were interactive; this means that students were given opportunities to voice out their ideas and teacher educators work with students' ideas. Hence, creating opportunities for students' participation leads to deeper engagement with the topics they encounter in the learning space. This is shown in table 4.1 above. Students utterances

were seen with the highest occurrence in Ms. Rose's lectures on Mitosis cell division with 73. Similarly, students' utterances were observed with the highest frequency seen in Mr Jonah's lecture with 67 in his second lecture on models of population growth. This range of students' utterance was seen by both Dr Lydia and Dr Charles with occurrences of 20 and 18 respectively. These students' utterances were facilitated by teacher educators sparking interaction and eliciting students to contribute to the meaning-making process in the course of their lectures. According to Tytler and Aranda's (2015) interaction in the classroom is the premise of the way teacher education responds to students' contributions. This explains the variation in the instances of students' utterances seen in the table above. The way teacher educators created opportunities by initiating discussion in their lectures differs hence, the differences in students' utterances for different lectures. At different stages, all teacher educators employ questions and prompt to facilitate discussions. Teacher educators' questions and prompts both trigger discussion. However, when questions seek a specific scientific view, the interaction was constrained. Where interaction was constrained was seen in Dr Lydia's lecture on aerobic respiration with five students interacting in a whole class and Dr Charles's lecture where he took an authoritative stand to explain a task to his students. Teacher educators' solicitations yielded different communicative approaches as shown in table 4.1. Where teacher education invite contribution in the form of solicitations and opportunities for more students to respond is seen in Ms. Rose's last lecture with 26 students contributing to the lecture and Mr Jonah's second lecture with 13 students involved in the lecture. The flow of dialogic interaction where preservice teachers feel encouraged to contribute to the whole class discussion is necessary for the co-construction of knowledge Alexander (2014). This is relevant to the Vygotskyian perspective on teaching and learning (Vygotsky, 1978). Students are taught science concepts in the course of lectures and these concepts have to be acquired over some time. The new concept represents a new reality for students. The theory that informs my study of the Vygotskian sociocultural views of effective learning of scientific concepts is that students should be exposed to deliberate choices and their ability to justify and internalise the concept they are exposed to they are then able to reason about this concept (1934 p.279). This means that the appropriation of concepts taught by educators happens over time in the science classroom. Hence, teacher educators are critical for creating opportunities for interaction through the use of all the resources in their environments (content, artefacts, peers, and educators).

4.5 Results from the Interviews with teacher educators

The transcripts of the interviews were analysed both inductively and deductively. The conceptual perspectives that informed this study influenced the deductive approach. I extracted the codes from the first transcript and refined them to reflect preservice teachers' perspectives on classroom activities encountered during lectures. Patterns identified in the data are selected coded and categorised as part of qualitative data analysis (Bruce, 2018). Ten categories eventually emerged across four transcripts. Starting out, predetermined categories and topics were chosen in line with Hatch's (2002) recommended procedures, and these categories were influenced by the study questions**.**

Codes emerging from interview data:

- Use of visuals to facilitate interaction and create opportunities for learning.
- Use of different strategies to create opportunities for learning
- Use of questioning prompts to create opportunities for learning and modelling of practice
- Use of Collaborative activities as opportunities to learn
- Employing small communities of practice as opportunities for learning.
- Use of discussions within lectures
- Teaching students how to build content
- Teaching Identity building to students
- Teaching humanistic approaches to students
- Use questioning to create awareness of the sequence of the CAPS document. (See appendix F for the description of codes).

Mr Jonah created opportunities to learn by engaging preservice teachers with a question, In the design of his lecture slides provision was made for students' involvement thus less text was used to create opportunities for soliciting ideas from preservice teachers. Mr Jonah believes by bringing coherence to his teaching by linking all content as he builds his science story over the time of his engagement with his students. Mr Jonah seems to address the issue of continuity in his content delivery. This is obvious in his concern about his students linking their current understanding with the prior knowledge and the coherence of the topic or concept in his process lectures or content delivery.

Dr Charles as an educator is also concerned with his students' previous understanding of life science topics they were taught before his lectures. So he is interested in creating opportunities for students to learn new concepts or new science content (Biggs, 1993). So

he engages his students with curriculum materials to capture their interest so that they will be motivated to learn.

Ms. Rose believes in engaging her preservice teachers with questions not the transmission of facts this is evident when they have to create opportunities to learn through conversation and instructional activities or voicing their understanding of the concept of discussion. The process of mediation is in line with the sociocultural theory employed in this study (Vygotsky, 1978).

Dr Lydia believes in the role of conversation as a key to the dynamics of classroom interaction and learning of science and hence, opportunities to learn. Dr Lydia creates opportunities in her lectures by employing questions probes and prompts.

Example of the coding process

Mr Jonah: First for my lectures, I design the PowerPoint slides in the sequence of my teaching units. Normally in biology, we say it is about relating the structure and function. So what I do is I limit the text in the slides and I put the structures of diagrams but is not only that it also includes how I sequenced the diagram and the text. So let's say I am talking about the concept of ATP or let me just say a concept of a lung and I want to explain the function of the lung. I will put the structure of a lung **(use of visuals on slides)** and engage students with questioning asking them what do you see the structure looking like (**use questions relating to projected images to engage students)** what are some of the things you can see from the structure and they will tell me use questions relating to projected images to engage students. Then I will proceed to ask them why do you think the Lung is like this here? (**Use questions relating to projected images to engage students).** Then we will have a discussion around those engage students in discussion So on the slide I will only have that structure and nothing else so we have a discussion and we continue. In the next slides, I will have key points of the information that I want to get. **(Use of visuals on slides)** So they don't first see the text but the structure then the text and then that helps us to engage for key points before and then I consolidate the discussion.

4.6 Focus group interview with preservice teachers

The audio-recorded focus group interview was transcribed by me. To become acquainted with the data generated, I read through the interview transcript to comprehend how teaching activities assist preservice teachers in learning science concepts. After becoming acquainted with the data, I coded it. My conceptual framework for the study guided my data coding. I sought out opportunities for preservice teachers to discuss the activities or tasks they were working on. The transcripts of the interviews were analyzed both inductively and deductively.

The conceptual perspectives that informed this study influenced the deductive approach. I extracted the codes from the first transcript and refined them to reflect preservice teachers' perspectives on classroom activities encountered during lectures. I've included a coded interview with a preservice teacher focus group below.

An excerpt from focus group interview

Interviewer: What has the experience of discussing in (task/assignment]) been like for you as a student?
Motomo: My experience is more like hers. **Working with my peer boost my confidence (ease of interaction)** because they are my peers they could understand me .And I have gained a lot from them because they **enhanced my ideas on some concepts(facilitate the process of meaning making)** and content yeah that is basically like hers
Lebo: also with me group work has being helpful as we **learn especially life sciences** Because we have different areas where some are strong and some are **weak and group discussion (peer meditation)** is where you help each other. Through our weak point and strong points.
Sapiso: My contribution is similar to hers; we get to learn from our peers they get to **enhance our ideas and what we know (learning from peer mediation).** And we relate more to our peers than and it has help me a lot in that part.
Lerato: okay I think working in group has being beneficial as you know we are people we bring **different prior knowledge (playing a role)** that we bring into and different experiences. So sometimes there might be a point that I might have missed in class and my **peer may enlighten me (understanding of concept)** on the point that I have missed.

Using the first coded first transcript, I coded the other interview transcript as being inductively open to students' ideas about the task they are assigned to undertake in lectures with their peers. The new codes that emerged were the result of the inductive analysis approach and are mostly about students describing themselves and their motivation to freely engage with their peers. Below are the final codes that emerged from the focus group interview.

- Life sciences as experts
- Playing a role
- Peer mediation
- Evidence of success on the task
- Taking ownership of learning.

4.7 Document Analysis

Documents in this study were the teaching PowerPoint slides. The purpose of collecting the documents was to investigate how they were used to engage students cognitively in creating opportunities for learning concepts taught to students.

Using PowerPoint slides, the teacher educators designed their lecture notes to facilitate student discourse-building questions that required students to respond. The slides were designed to facilitate different types of engagement with the content of the lectures.

Mr Jonah's first ten PowerPoint slides introduced the concept of Population. To familiarise his students with the topic, he will lay a foundation for the topic. The remaining 17 slides deal with other aspects of the course, such as population growth, death rate, birth rate, and carrying capacity of the environment.

In the first three PowerPoint slides of the presentation, Dr Charles explains the purpose of the course, and then discusses the course and concepts of environmental education. His slides always include a question to prompt students to reflect on their learning. The slides provide an assignment at the end of the course.

In her PowerPoint slide design, Rose divided the cell introduction into two parts: structure and function of the cell. Twenty-three slides were dedicated to the introduction to cells and twenty-eight slides to the cell structure and function. In her slides, she shows a variety of types of cells (plants/animals), as well as specialised cells (blood cells, nerve cells).

Dr Lydia's PowerPoint slides were designed with the first few slides being an introduction to the biochemistry of respiration and question to trigger students' thinking about the course. She introduced on her slides complex concepts of aerobic and anaerobic respiration as the course progressed. The last seven slides summarised what she taught her students in the last class. The PowerPoint slides of all the teacher educators were used to prompt student responses to ensure that opportunities are created for students to understand the topic of discussion hence, engaging socially in the social space and cognitively for meaning negotiation process.

4.8 Chapter summary

In this chapter, I present the findings of this study based on the analysis of teaching transcripts generated from my lecture observations of teacher educators and their interviews

revealing their ideas of their practice about their instructional activities. In the next chapter, I present details of opportunities created by the participants in their lectures

CHAPTER FIVE: DETAILS OF OPPORTUNITIES CREATED BY TWO EDUCATORS IN THEIR BIOLOGY LECTURES

The focus of my study was to investigate how teacher educators create opportunities for learning in a lecture setting. In this chapter, I present the discussion of how opportunities were created by two participants Mr Jonah and Dr Charles. I present a case-by-case analysis of teacher educators and their lessons. This is to gain an understanding of each case as a separate entity and its context (Starman, 2013). A case study is undertaken to address how and why questions as human behaviour cannot be altered by the researcher (Yin, 2009). So I wanted to understand the mediation offered by teacher educators and the resultant interactions that followed suit leading to sustained engagement of preservice teachers with the topic of the discussion thus creating opportunities for co-construction of meaning in lectures (Mortimer & Scott, 2003).

As mentioned in chapter three Mr Jonah taught five topics of population ecology and Dr Charles taught two topics of environmental studies. Table 1 below shows an outline of the population ecology topics that were taught by Mr Jonah.

Table 5.1: Lecture topics taught by Mr Jonah

Lesson	Date	Topic	Year of study	Recording	lesson duration
Lecture 1	18/9/2017	Characteristics of populations	3	A	50min
L J 2	22/9/2017	Models of population growth	3	A	50min
L J 3	27/9/2017	Density-dependent and density-independent factors affect the population size	3	A	50min
L J 4	29/9/2017	Interactions in the environment	3	A	50min
L J 5	2/10/2017	Human population growth	3	A	45min

Teacher educator Mr Jonah's class was the first lecturer to be observed. I gained access to his lectures to observe his practice. I observed all the five topics he taught to generate data for my study. Mr Jonah was a novice teacher educator but he has some experience and knowledge about teaching as teacher talk and learner understanding of science content was his research area for his masters' dissertation.

5.1 Opportunities for learning that were created in Mr Jonah's lecture

Analysis of Mr Jonah's five lectures showed the manifestation of seven categories of opportunities created during his lecture delivery, these are given below:

Category 1 TE introduces concepts with questions without providing answers

Category 2 TE probes preservice teachers for elaborate meaning for clarity

Category 3 TE review the student's response and gives further explanation

Category 4 TE uses PPts slides to illustrate a concept

Category 5 TE explains verbally only

Category 6 TE uses illustrations on the board

Category 7 TE employs preservice teachers with mind-engaging activities

Table 5.2: below shows the frequency of occurrence of each category across the five lectures

	Lecture 1	Lecture 2	Lecture 3	Lecture 4	Lecture 5
Category 1	6	0	1	1	1
Category 2	13	15	11	18	3
Category 3	5	11	1	3	1
Category 4	8	14	4	7	13
Category 5	22	46	32	14	10
Category 6	2	1	0	1	0
Category 7	7	1	1	3	0

Below I present how Mr Jonah created opportunities to learn based on the categories that emerge from data.

Excerpt 1

Category 1: TE introduces concepts with questions without providing answers

As can be seen in Table 5.2 above, Mr Jonah created opportunities to learn several times by using questions to introduce concepts that he was going to teach. I provide examples below. In lecture 1 which was 50 minutes long, he introduced the following concepts by use of questions: ecology, population ecology, population growth, Interactions in the environment, factors that affect the population size, and human population growth.

The excerpt below shows how Mr Jonah introduced these concepts and the interaction that ensued.

L: Okay, if you are saying population ecology is the study of various populations; how do you differentiate it from community ecology?
This prompting encourages students to think of an answer and therefore by prompting students with questions, the lecturer creates opportunities for learning as students have to engage with the questions/prompts to respond

S3: Community is various populations and the populations, is, the human population and how they interact with the environment.

The same student here responded again. And finally the educator Jonah then gives an evaluation and further explains the concept of ecology by looking at how the organism interacts in the environment and elaborates with two additional concepts of biotic and abiotic factors. His explanation is given below.

L: So, with ecology, yes it is correct… we are looking at how organisms interact in that environment. We are looking at both biotic and abiotic factors…and they have levels, we will talk about levels just now. With population ecology, we are looking at how different populations increase and decrease based on different factors.
This is how this first excerpt ended. Mr Jonah used open-ended questions (not one-word responses) to get students' responses until he finally scaffolds the students' responses with a detailed explanation in the ongoing lecture encounter with his students. I provided two more examples below.

S5: Intra is amongst organisms of the same species and inter is amongst individuals of different species.
L: So, intra is amongst organisms of the same species and inter is of different species.
So, when we started, we said we are studying population ecology but if we talk about competition, we are stepping into community ecology because we are talking about two different species and therefore two different populations. So, interspecific competition explains the concept of ecological niche. Have you heard of this concept before?

As can be seen above, Mr Jonah used a question to introduce his first lecture which was on the characteristics of populations, the concepts of ecology and population ecology. After posing the question, Mr Jonah waited for the students to respond. After a while, a student responded. By posing a question and waiting for students to respond, Mr Jonah created a learning opportunity. Research shows that wait time allows students to process their responses and hence has an impact on the process of learning (Mahmud, 2019). After the student's response, he asked the class for additional contributions. The TE did not provide an answer to the student's response but probed further with a follow-up question. The same student here responded again. And finally the educator Mr Jonah gives an evaluation and further explains

the concept of ecology by looking at how the organism interacts in the environment and elaborates with two additional concepts of biotic and abiotic factors.

Mr Jonah deliberately provided opportunities for active participation (Oliveira, 2010) to his preservice teachers in the course of his lecture delivery. Students were attentive to Mr Jonah's solicitation for a response. However, few responded to his invitation to contribute to the whole class discussion.

Asking a question and then waiting for students to answer as a teaching strategy encourage encounters with life sciences content and promotes discussion with the whole class and check their prior knowledge. The teacher–student interaction offers an opportunity for the whole class to contribute to the invitation by Mr Jonah and is necessary for preservice teachers to articulate their prior knowledge and provide an emerging understanding of the topic of discussion. Hence, the role of Mr Jonah in facilitating productive interaction with preservice teachers agrees with Soter et al. (2010) notion of the need for to be a gradual sharing of responsibility in the teaching and learning process. This type of interaction is important in the meaning negotiation process (Vacca, 2013). **However, whole class discussion can be difficult to engage some groups in vibrant discussion. Not all students are given a voice. Many whole group sessions feature a small number of vocal students eager to voice their perspectives and a bigger group of relatively quiet students who blend into the walls.**

Category 1 as shown in Table 5.2 above, the frequency of occurrence was visible in the first lecture and only appears once in the third to the fifth lecture.

Mr Jonah in the introductory lecture solicited students' contributions. However, in the third and fifth lectures, Mr Jonah's' Category 1 was less visible but probing sessions were followed to encourage interaction in the lectures. Mr Jonah, however, employed other strategies to create opportunities for facilitating interaction in his lectures. Research has shown that student-led interaction designed to elicit and sustain multiple contributions from students would lead to more productive interactions between teachers and students in the classroom if they are used effectively (Cian & Cook, 2018; Msimanga & Lelliott, 2012). An effective discussion in the classroom for students to contribute will require rephrasing the initial questions and probing students' ideas about the content of the discussion. Increasing student participation through whole class discussion is an important pedagogical tool, as it allows the teacher educator to influence student conceptual understanding in ways that impact

meaningful learning, according to (Morton, 2012). The excerpt below shows how Mr Jonah introduced these concepts and the interaction that ensued.

Excerpt 2

Category 2: TE probes preservice teachers for elaborate meaning for clarity

L: Okay, so how are they different from density-dependent factors?
S2: Density-independent means the environmental factors that change the population size. So, it could be a storm, tornado, and…yah
L: Okay. Somebody at the back? Yes, sir? Can we have say something? Right at the back…Okay, any other contribution? What do we mean by a model? In general terms, or in biology or in mathematics?

Mr Jonah engages his students with probing questions as shown in the excerpt above to build the scientific story in his introductory lecture and foster deep engagement for learning in this lecture (Tekkumru-Kisa et al., 2015). This teaching practice supports the new science education reform (NRC, 2015). Probing students provide the class with an opportunity to verbalise their ideas and hence encourage knowledge sharing (De Vissher et al., 2018). McGregor (2007) argued that probing preservice teachers shapes their thinking in the social community. Probing students for their contribution means that Mr Jonah had the awareness that students come to lectures with prior knowledge and he employs the students to respond to his probing in the knowledge negotiation process. Probing by teacher educators is a constructivist approach to teaching. The communicative approach was interactive as students were engaged by the educator with questioning probes as opportunities to learn. Next, I discuss the third category of finding in this study.

Excerpt 3

Category 3 TE review the student's response and gives further explanation

L: So, if we talk specifically about human population, we are looking at how resources are distributed.

TE reviews a student's response and further explains the concept.

So, by knowing that Wits School of Education we have 3000 students…that is the population in this campus…so they know how they can distribute the computers and everything. TE further clarifies that knowledge of population concept will help in resource distribution.

So, is per unit area at a given time and that is very important because when ecologists study a certain population, they look at that specific area. In the excerpt above Mr Jonah in his second lecture delivery reviewed a student's response and gives additional explanation.

Mr Jonah is using different teaching procedures to introduce concepts in his second lecture in contrast to his first lecture where he uses questions to introduce concepts without providing answers. Finally, in these lectures, he uses a visual representation to engage his students explaining survivorship curves to bring clarity to the students as he builds the scientific story this type of engaging process of questioning interspaced with explanation facilitates meaningful learning (Morton, 2012).

Mr Jonah created opportunities for his preservice teachers to learn in his second lecture starting his introduction of concepts with an explanation then he opened up spaces of interaction with questions. This was shown in the summary of Table 5.2 above with verbal explanation having the highest frequency of 46 followed by probing with questioning with a frequency of 15. Then the review of students' contributions at 11 frequency of occurrence and his use of PowerPoint as a mediating tool to his students learning featured 14 times. Finally, in this lecture, the use of chalkboard illustration and use of activities to engage the cognitive abilities of his preservice teachers featured once each. An interesting feature of the summary of opportunities created by Mr Jonah in his second lecture is his occurrence of verbal explanation. However, focusing on the probing of students' contribution as the opportunity under discussion here, brings clarity to the concept introduced in the course of the whole class discussion and provides a platform for deeper understanding (Cian & Cook, 2018). This is what Tytler and Aranda (2015) argued in their model of discursive function as a teacher move that brings clarity to the type of interaction between teacher educators and students. This Category 2 was featured with the highest occurrence in Mr Jonah's fourth lecture occurring 18 times followed by the second lecture 15 times and 13 in his first lecture and 11 times in his third lecture with the least occurrence in his last lecture. This teacher-educator move is necessary both to shape the students' ideas and acknowledge their contribution.

I provided an example below. Category 4-TE uses PPts slides to illustrate a concept.

Excerpt 4

L: So, we have three types of survivorship curves. On the x-axis, you have the age and on the y-axis, you have the number of survivors. We have three types of survivorship curves.

TE explains the general survivalship curves in organisms and uses the PPts slide for clarity for the class

Next, I provided the opportunities created in Mr Jonah's third lecture density-dependent and density-independent factors affect the population size

Today we are talking about population regulation by density-dependent and density-independent factors. But before we do that, I just want to talk about what we did on Friday. So we said that to determine the change of population growth, we use the formula $\frac{\Delta N}{\Delta t} = rN$. This is a generalized equation. And we have two models and those are geometric and logistic. The difference is, with the geometric model, there is an increase…so it adheres to the biotic potential. So, the population can increase because there are no limitations in the environment. So, today we are looking at how populations are regulated by density-dependent and density-independent factors. In the first lecture, we talked about what we mean by density. It is about the number of individuals in a particular area.

The TE explains verbally only

L: So, what do you understand by density-dependent and density-independent?

The excerpt above shows how in his third lecture Mr Jonah introduces concepts first with an explanation employing PowerPoint slides and then ask probing question for his students to respond to his teaching. Student two above responded to the teacher educator's probing. However, the educator did not answer but rather probes further to engage his students in participating in meaningful negotiation (Skott, 2015). Student three responded to Mr Jonah's probing and finally the educator gives an evaluation saying they were partially correct and elaborated further to bring clarity for the whole class. Furthermore, the discussion was continued by student three asking for clarity about density-dependent factors and competition. Mr Jonah responded to her question by explaining that crowding and disease are also factors that can act on a population. Mr Jonah engaged his students with probing questions to foster deep engagement in learning in this lecture (Tekkumru-Kisa et al., 2015). This teaching practice is in agreement with the new science education reform (NRC, 2015). The lecture pattern in Mr Jonah's third lecture delivery is similar to his second lecture where he introduced concepts with explanations and then probes his preservice teachers with questions. The third category of results emerging from data shows varying occurrences across the lectures observed with the first, second, third, fourth and last lecture of Mr Jonah 5,11,1,3, and 1 respectively as shown in Table 5.2 above. So the highest frequency of occurrence of this type of opportunity for students to learn was observed in Mr Jonah's second lecture 11 times. The highest occurrence of category two which is probing for students' responses is a practice of

Mr Jonah to challenge his students to engage cognitively with the content of the discussion. Research suggests that explanation and questioning are necessary processes of knowledge building. Hence, this practice of explaining concepts interspaced with probing questions is a necessary interactional process and signals students centred strategy (Bansal, 2018). The frequency of probing questioning is important in the course of lecture delivery. However, the strategic timing when to raise the probing questions as opportunities to reveal the students emerging understanding is key to the learning process (Fortus et al., 2015). Two excerpts as examples of explanation and questioning are provided below. Category 5 TE explains verbally

Excerpt 5

L: So, you are partially correct because, with the density-dependent, they are those factors that act on the population based on the number of individuals found in that particular population. And the density-independent are factors that are…. they are acting on the population depending on the size of the population. So if somewhere here (on the y-axis of the graph), we had a drought and all the individuals experienced famine, then we would have a drop in the population size. But then with density-dependent, the factors are dependent on the size of the population. So, as the population nears the carrying capacity, those factors become severe and they act on the population and the increase of population starts to become slow, therefore; regulating the population size. So an example here would be competition and an example of density independent would be an earthquake. Even if it is just the two of you, the earthquake will still come and kill you.

S3: So, now are you saying that density-dependent factors, it is the only competition that can…

L: No, no…there are others like crowding, diseases, and dead.

TE explains verbally only

92 S5: In the last lecture, you gave us that population pyramid as a way of explaining what is happening…reality; so, that is a model.

L: Okay. Do they entirely explain reality?

S5: No, not at all. Models are also faulty. They are not precise. Joseph?

S6: I am thinking of… (Inaudible); for example, water molecule…that is a model

L: So, we talked about a graph, a pyramid and you are talking about concrete things…so in mathematical terms, can we have something or an equation as a model?

S: Yes

L: It is the interaction between two organisms and that interaction; in most cases, the organisms are of different species. And we have three kinds of those interactions; we have parasitism, commensalism, and mutualism.
Some textbooks would classify…what are the words? Herbivorous…I can't remember the actual but it has to do with herbivores as an interaction. But we will be focusing on these three and they are classified according to whether they are harmful, neutral, or helpful to the species involved. In some cases, you find that one species benefits while the other is being harmed and in some cases, you find that both species are benefiting. Let's deal with the first one which is parasitism Yes mam?

Mr Jonah used verbal explanations to introduce new content and bring about clarity to concepts of discussion in his lectures. This instructional strategy where the educators explain content is a platform that provides students with an opportunity to ask for clarification (Aranda et al., 2018). Explaining concepts in a whole class setting is a strategy (Cian & Cook, 2018). Mr Jonah's verbal explanation and representation as part of his instructional delivery. Verbal explanation occurred more frequently than other categories of opportunities created for learning by Mr Jonah across his five lectures the highest occurrence was shown in his second lecture with 46 and the least in his five lectures with 10 and the first third and fourth lectures have frequencies of 22, 32 and 14 as shown in table 3 above. This is because an explanation is a major teacher talk moves to both introduce content and clarify any misconception of the content of the discussion. Hence, the high occurrence of verbal explanation at the beginning points to the scaffolding role played by Mr Jonah. I provide a discussion of how category 6 was used to create opportunities for learning in Mr Jonah's teaching.

Category 6 TE uses illustrations on the board

In this lecture, Mr Jonah introduces the concept using illustrations on the board and explained the interactions in a community of organisms and their effect on the organisms involved. He explained the types of interactions and opened an opportunity for discussion with a question (Sujarittham et al., 2016).

Student one responded and Mr Jonah reviewed the students' responses with further explanation for clarity and probed students for their understanding of parasitism.

However, Mr Jonah engaged PowerPoint slides as a tool for the review of students' contributions. This confirms (Ausubel, 1977) notion of advance organizer for the successful

acquisition of new content. The use of PowerPoint slides was the fourth category that emerges from the analysis of data. Mr Jonah employs the PowerPoint slides as a mediational tool to create an opportunity to learn. This category has a different frequency of occurrence across Mr Jonah five lectures with the first lecture having 8, the second lecture 14, the third lecture 4 and the fourth and fifth had 7 and 13 respectively. The use of representations of properties of biological phenomena at different scales has been found to be helpful in improving students' understanding (Arneson & Offerdahl, 2018). However, due to the complex nature of biological systems teacher educators need to design their lecture slides with the students in mind incorporating activities that engage the cognitive function of the students. Hence, the use of PowerPoint slides serves as a tool that supports learning and embraces the new reform in science education calling for active students' participation in the learning process.

Two examples of the categories of the use of the board and PowerPoint slides are provided below.

Excerpt 6

S2: I think it is when one organism is benefiting and harming the other one. R

L: So, one organism is benefiting and the other is harmed. So the organism is extracting nutrients from another organism which is called a host and an example would be that of a mosquito. A mosquito extracts nutrients from human beings harming the human and sometimes it causes malaria if that particular mosquito is the one that actually causes malaria; the anopheles one. So one organism (reads from the slide) is a parasite and in this case, a parasite would be a mosquito that derives its nutrients from another and another would be a human being and that is a host. So the interaction there is that one organism benefits while the other is harmed and that has implications for the growth of populations specifically the growth of the human population if we would be talking about the example of a human being and a mosquito. And we will see later on how that affects the population density and growth.

TE reviews students' responses and uses PPTs to illustrate the example of parasitism there are two types of parasites.

We have the ectoparasite and we have the endoparasite. What does echo mean?

Mr Jonah reviews student two contributions and elaborates further and uses PowerPoint slides to mediate the process of meaningful negotiation with the whole class. 'He probes further to engage the mind of his students to establish the clarity of the students' two contributions. Student one responded to educator Mr Jonah's probing question what does ecto mean? Mr

Jonah rephrases the student's response and probes for the meaning of endo. Student one answered the question and educator Mr Jonah finally reviews the student's response and gives further explanation. Mr Jonah's use of PowerPoint slides also serves as a support for the review of students' contributions. This extended session of probing questions by Mr Jonah encourages productive participation in the unfolding flow of the whole class discussion and engagement for learning (Cian & Cook, 2018; Msimanga & Lelliott, 2012).

Next, I provided the opportunities created in Mr Jonah's fifth lecture Human population growth

Excerpt 7

L: Okay, can we start? So, today we are talking about populations…with a focus on human beings and the big idea here is that the human population continues to grow whether it grows rapidly or slowly is explained by the factors affecting the growth. So, if you look at the history of human population growth, what are some of the things coming out of the graph (displays the graph on the slide)?

What can you say about that graph showing the history of human population growth? Thousands of years ago…up to now

S1: It has grown over the years

L: So, it has grown over the years. It has increased. Is there any model that you can use to explain that particular growth?

S2: Exponential

L: It is exponential. E So, it has grown but the growth has been slow.

After a disease which attacked Europe in the 1300s caused by a bacterium of the rodents it decreased and started to increase again following an exponential form. This can be attributed to what they called the industrial revolution where people had access to sanitation and everything was there where people reproduced rapidly and the death rate was lowered. It continues to grow because now we are sitting at 7.4 billion people in the world. But that is different from continent to continent and from country to country as we will see later on.

Mr Jonah introduces the concept of the human population using the graph on PowerPoint slides and opens an opportunity for discussion with an open-ended question. Student one responded and the educators reviewed the response and probed further for elaborate contributions. Student two responded and finally, he gave a verbal explanation to bring about the clarity that will facilitate learning (Aranda et al., 2020).

Excerpt 8

L: So, when we talk about dispersion…dispersion is different from dispersal. During pollination, the seeds or pollen grains undergo the process of dispersal but dispersion is about how individuals in a particular population are distributed

TE uses verbal explanation to differentiate between dispersal and dispersion

So, clumped dispersion, we get individuals here (drawing on the board – dots to represent organisms on 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 (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, individuals 1 and 2 (naming the dots as individuals) is the same.

TE uses verbal explanation to elaborate further on the concept of dispersion as clumped random and uniform

But one thing that you need to know is that they are not static. These dispersions are not static. So, the very same population which shows clumped dispersion would show a random or uniform dispersion at some point. It is based on behavioural activities. For example, the butterflies would be clumped for a certain activity and then they would disperse if they are going to mate or something like that.

TE reiterates that dispersion in a population is not static but is based on behavioural activity.

Excerpt 9

L: So, the idea behind this (the question of the activity) is that…I think I have already explained this. So, if you have a pyramid like this (draws on the whiteboard) you can see that here, between the age of 15 to 25, we have more people. So, it means that there are high chances that the population will increase. But if you have something like this and it looks like this at the bottom (draws another example of a population pyramid); chances are, that particular population will collapse because these people at the top there are no longer reproducing but the people here have high fertility rate but there is less of them than here.

TE uses illustrations of the population pyramid on the board.

Of particular interest here, I want to focus on the quadrats and the mark-recapture method. With the quadrats, they use something like that (pointing at the picture on the slide).

The size of the quadrats depends on the area of the land that you want to investigate. So, you would need to know the area of the land or the habitat. And you need to know the area of the quadrat (writing on the board). The other thing is that you would need to know the number of organisms that you get in each quadrat as your sample.

A lecture delivery of Mr Jonah's teaching proved to be the only source of this finding in contrast to the three cases. Mr Jonah's use of illustrations on the board allows him to vary the pace of his lectures, as preservice teachers need time to absorb information. With this, Mr Jonah can adjust the content he gives his preservice teachers and also adapts the way he delivers his lectures. This finding points to the relevance of the board to manage a large population of students with illustrations on the board. The frequency of illustrations on the board as shown in Table 5.2 above featured in three lectures of Mr Jonah. The use of illustrations on the board improves teaching effectiveness by easing classroom management as students are involved (Bowen, 2009). The board serves as a platform tool to encourage note-taking for students. Integrating the use of illustrations on the board and also the use of PowerPoint slides both engages students and motivates them in the teaching and learning process.

Mr Jonah's slides cover a limited amount of text and diagrams. By guiding preservice teachers through the use of probes in the text, he encourages them to express their understanding of the topic under discussion. The frequency of probing questions and the timing are necessary as argued by (Reiser et al., 2017) for high levels of engagement with science content. In addition to text diagrams and probing questions, each educator uses a varying spread of text examples to engage pre-service teachers. Using PowerPoint slides in lectures is to let biology students traverse complex biological visualizations with large numbers of students, (Arneson & Offerdahl, 2018). The use of mediating tools in form of PowerPoint slides was featured across the three remaining cases. Mr Jonah restricts the text in the slides and emphasises the structures of diagrams. He employs the text to scaffold preservice teachers with probes as they voice their understanding of the whole class discussion. Hence, the delivery usage and design of this mediating tool vary. PowerPoint slides are used by Mr Jonah as a tool to facilitate learning. The purpose of PowerPoint slides is to support learning and use a biological representation of diagrams. Next, I discuss the last category of finding in Mr Jonah's teaching.

Category 7 TE employs preservice teachers with mind-engaging activities

L: But, what I want you to think about now is why do you think individuals would be clumped in a specific range?

TE asks a question to deeply engage the mind of his preservice teachers.

Why do you think individuals would exhibit a random spacing or a random dispersion? Why do you think that individuals would exhibit a uniform spacing?

TE assigns an activity to the class.

So, in your activity, you need to think about why…

TE gives further instruction on preservice teachers' tasks.

So think about why individuals in a population would be clumped, random, and uniformly spaced.

TE gives further instruction for the preservice teacher to engage their mind to answer why different types of dispersion in a population.

So, I am giving you 5 minutes at most…absolute silence, I want you to think of the question and write down your thoughts.

TE instructs preservice to think and write their thoughts

In the excerpt above Mr Jonah exposed preservice teachers to productive interaction and sense-making of concepts, engaging in activities that challenge their cognitive abilities is essential. The use of activities to engage the minds of students as opportunities to learn is in agreement with teaching practices (Bosman, 2015) that place students at the centre of the teaching /learning process. This use of mind-engaging activities supports the call for the transformation of instructional practices assigned to students (NRC, 2015) the use of mind-engaging activities as an instructional strategy was employed by Mr Jonah. Mr Jonah engages his students cognitively and socially with illustrations on his PowerPoint slides to engage the mind of his preservice teachers in a shared social activity demanding preservice teachers to think together. These activities are questions to respond to, and finally visual prompts from his PowerPoint. Mind-engaging activity as shown in the Table 5,2 above from the first lecture appears 7 times followed by once in both the second and third lectures and finally 3 times in the fourth lecture. Mr Jonah's fifth lecture was void of this category. Mind-engaging activities require students to both understand phenomena and engage deeply with activities towards

providing answers. Engaging in activities that place a demand on preservice teachers' cognitive ability is necessary for the meaningful negotiation process. Research suggests that mind-engaging activities are a necessary opportunity for learning (Tekkumru-Kisa, et al., 2015).

5.2 Results Interview with Mr Jonah

In this section, I present findings from interviews with teacher educators about their practice with a large population of students in a teacher education programme.

In this section, I present analysis and findings from the face-to-face interview with Mr Jonah about his ideas of lecture delivery with his students in life sciences classrooms. I also inductively analyse three remaining educators' interview transcripts, the interviews are found in appendix F.

Mr Jonah interview demonstrates how he plans his lecture delivery to engage his students both cognitively and socially in the social space of the classroom. To engage his students Mr Jonah designs his slides to engage his students with the concept of the topic of the discussion thus facilitating interaction in the whole class. This opens spaces for students to bring their ideas to the classroom discussion thus facilitating students to talk in their content delivery. Mr Jonah facilitates interaction in his lectures by engaging preservice teachers with a question and even the design of his lecture slides provision was made for students' involvement thus less text was used to create opportunities for soliciting ideas from preservice teachers. The educator brings coherence to his teaching linking all content as he builds his science story over the time of his engagement with his students. Mr Jonah seems to address the issue of continuity in his content delivery. This is obvious in his concern about his students linking their current understanding with the prior knowledge and the coherence of topic or concept in his process lectures or content delivery

5.3 Discussion of Mr Jonah's lecture delivery

The results of Mr Jonah's lecture delivery reveal the categories that were displayed in Table 5.2 above shows that verbal explanation and PowerPoint illustrations featured with a high frequency of occurrence across the five lectures observed to generate data. This suggests that Mr Jonah is using talk as a tool and PPts as a mediational tool to support his student's

understanding of concepts they encounter in the social plane. Mr Jonah employs questioning as indicated in Category 1 in Table 5.2 above without providing answers. This teaching procedure is an invitation for his students to participate in the discussion about the topic of his teaching. These categories manifested with all the teacher educators observed to generate data. The invitation for contribution from Mr Jonah is followed by probing in Table 5.2 above when a student responds. The probing to elaborate for clarity is an effort by the educator to mediate the meaning negotiation process. In this first category that emerges from data, the teacher educator introduces concepts with questions without providing answers manifested across all the teaching transcripts of all four educators observed. These results corroborate the suggestion of Johnson and Golombek (2016) that preservice teachers need the invitation to participate actively in social learning environments. In addition to soliciting responses, educators can also work with preservice teachers' prior learning by asking questions rather than providing answers (Hofferber et al., 2016). The opportunities created by Mr Jonah in his lectures for category one initiating discussion with questions without an answer he follows with sessions of probing for additional contribution from his students. However, after responses from students provide desired or correct feedback he reviews the contribution and brings clarity with detailed feedback.

Category 2 TE probes preservice teachers for elaborate meaning for clarity

Category 3 TE reviews student's responses and gives further explanations,

Category 4 TE uses PPts slides to illustrate a concept, and five manifested across all four educators.

Mr Jonah used diagrams on his PowerPoint slides to engage the mind of his preservice teachers in a collective activity with questions that will demand preservice teachers to think together to provide explanations for the instructional activity. The thinking about the activity calls for preservice teachers to engage in deeper understanding as explicit instruction was given by the educator "what I want you to think about now is why you think individuals would be clumped". The essence of probing for clarity and reviewing students' responses or verbally explaining concepts is to establish the realisation of the potential offered by the opportunity to learn. This is because learning is seen through sustained, engaged participation in classroom experiences.

Mr Jonah in contrast to the other educators employs the use of the board in his lecture space to explain the content of discussion in his lecture as reflected in Category 6. This is in

agreement with the suggestion that teaching strategies and available resources in the social space enhance the process of meaning negotiation (Kang et al. 2016; Tekkumru-Kisa et al., 2015). The use of PowerPoint slides supports the call for increased exposure for visual literacy of biology students (Arneson & Offerdahl, 2018).

5.4 Opportunities for learning that were created in Dr Charles's lectures

Teacher educator Dr Charles was the second lecturer whose lessons I observed. I observed both that he taught to generate data for my study. Dr Charles is a seasoned teacher educator with a wealth of teaching experience in environmental studies. I took all that I observed because his lectures coincided with the end of the fourth block which was a short period at the end of the year 2017 academic session.

Table 5. 3: Lecture topic taught by Dr Charles

Lesson	Date	Topic	Year of study	Recording	lesson duration
1	9/10/2017	Introduction To Environmental Studies	3	A	55min
2	16/10/2017	The state of the planet today	3	A	35min

I observed two lessons totaling 90 minutes.

5.4 Opportunities for learning that were created in Dr Charles lectures

Analysis of Dr Charles lectures showed the manifestation of nine categories of opportunities created during his lecture delivery, these are given below:

Category 1: TE introduces concepts with questions without providing answers

Category 2: TE probes preservice teachers for elaborate meaning for clarity

Category 3: TE review the student's response and gives further explanation

Category 4: TE uses PowerPoint slides to illustrate a concept.

Category 5 TE explains verbally only

Category 7 TE employs preservice teachers with mind-engaging activities

Category 9 TE introduces concepts creating a scenario

Category 10 TE uses verbal explanation only to introduce a concept

Category 11 TE uses a video clip to introduce a concept

Table 5.4 below shows the frequency of occurrence of each category across the two lectures

Category	Lecture 1	Lecture 2
Category 1	15	0
category 2	7	0
Category 3	6	0
Category 4	4	1
Category 5	17	7
Category 7	7	0
Category 9	1	0
Category 10	4	0
Category -11	2	0

Category 1: TE introduces concepts with questions without providing answers.

Excerpt 1

L: What is a human? Are you human?

Ss: Yes we are.
L: What makes you human?
TE probes for elaborate responses from the students

L Talk to your neighbour first before you talk to me.
TE engages students in mind activities

C: [discussing] 1:20 seconds …….
L: What do humans do? Teachers, what do humans do?
TE rephrases his questions for clarity

L: YES?
TE probes for the class response

S3: thinking
L: What kind of thinking do they do?
S4: Metacognition
L: Metacognition. Repeating the ability to think ahead and the ability to reason
TE reviews preservice teachers' response for clarity

L: Any other responses?
TE probes further for the class response

S5: phenotype

L: What is phenotype?
TE introduces a concept with a question

S5: We have a common outward appearance
L: Yes we look alike but we look like gorillas don't we?
TE ask mind engaging question

L: Give him a chance to explain.
S: Humans relate with each other
L: YES humans can relate to different humans. So when you see a gorilla you can tell this one is my relative. Many times I am on the road on a bus driving with friends. I see monkeys and baboons, and what do I say 'hey relative…
TE reviews students' responses and elaborates further for clarity

Dr Charles introduces a concept without answering and pauses for students' contribution as shown in the excerpts above but when there was none, he asked a follow-up question. The questions gave a platform of social interplay on the social plane and help stimulate students to think (e.g., Chen et al., 2017; Chin, 2007; Oliveira, 2010; Wei et al., 2018). The students responded with a chorus answer to the question Are you human? Dr Charles probes further allowing the students to interact with their peers. Dr Charles further probes communicating with his class students' participating and finally, he scaffolds the students' response with an elaborate explanation. As shown in Table 5.4 above, the Category 1 frequency is 15 and it only manifested in his first lecture his second lecture was preparation for his students to participate in role play. Research shows that wait time supports cognitive processing of new information (Iksan & Daniel, 2015). Hence, Dr Charles probing session was to encourage students' active participation in the learning process and shape their responses (Tytler & Aranda, 2015, p. 432). This finding suggests the critical role of teacher questioning to facilitate thinking and exploring students' contributions (Chin, 2007). For Dr Charles in this teaching category, in contrast to Mr Jonah, when he creates opportunities for learning with questions, he shares responsibility to students to discuss with their peers after a short wait time for response. This peer interaction creates a platform for peer mediation of learning through discussion.

Next, I provided the second category of the opportunity created in Dr Charles's lecture

Excerpt 2

Category 2: TE probes preservice teachers for elaborate meaning for clarity

L: What are your views about decolonization? Yes, there is no wrong answer place.

TE probes preservice teachers for their responses

Anyone else?

TE probes preservice teachers for a more elaborate response for clarity

Any other comment. Okay, there is something about liberating education. Education must be liberating.

TE probes preservice teachers for a more elaborate response for clarity

What makes you human?

TE probes for an elaborate response from the students

Yes?

TE probes for the class response

Any other responses?

TE probes further for the class response

Some of you remember that the Americans and the Caribbean were led by a few tides by two cyclones in the past few months. And anyone who can recognise this?

TE probes preservice teachers for more elaborate response

Category 2 as shown in the Table 5.4 above features 7 times in Dr Charles lecture one and none in his second lecture. In the excerpt shown above, Dr Charles engages preservice teachers in the elaborative invitation to contribute to the whole class discussion, and interrogates contribution for an additional contribution. This is key to active participation in the construction of knowledge (Hardman & Hardman, 2017). These instances of participation may lead to deeper engagement with the content or topic. This probing question creates opportunities for the voices and ideas of students to be accepted or refined as they engage with science concepts. Research reveals that elaborative strategies assist the learning process in classrooms (Andre, 2013; Dunlosky et al., 2013). Reusser et al. (2015) argued that teaching

practices such as student-centred strategies of elaborative invitation are paramount and central to science learning. Khoza and Nyamupangedengu (2018) posited that teacher-probing questions that challenge the students to contribute, signal student-centred interaction which is relevant to the meaning negotiation process.

Next, I provided the third category of the opportunity created in Dr Charles's lecture

Category 3: TE review the student's response and gives further explanation

Excerpt 3

L: Metacognition, Repeating. The ability to think ahead and the ability to reason for clarity Any other responses?

L: Yes humans can relate to different humans. So when you see a gorilla you can tell this one is my relative. Many times I am on the road on a bus driving with friends. I see monkeys and baboons, and what do I say 'Hey relative'?

TE reviews students' responses and elaborates further for clarity

L: Okay but those relatives of ours may not be able to communicate in the same manner as I do with people on the same vehicle. So we have that ability to relate and as we were relating to coming up with this answer. We had one way of relating.

TE reviews student's responses and elaborates further for clarity

L: I am not denying that animals relate but we relate as humans. and elaborates further for clarity

TE reviews student's responses

So I will not relate with gorilla my relative but I relate with you (students) in many ways.

L: One aspect of humanity is the ability to relate with each other. So when we are talking about education, education must be able to create those opportunities for us to relate with each other in different ways. So what I mean by education should be humanising is that education should provide opportunities for the learners to relate amongst themselves. Because the traditional form of education is such that learners compete if anyone knows anything they fold their hands and they don't say anything but the structure of education allows the learners to interact amongst themselves so that they come up with shared knowledge.

TE reviews student's responses and elaborates further for clarity

In the Category 3 as shown in the Table 5.4 above features 6 times in Dr Charles's lecture one and none in his second lecture. In the excerpts shown above Dr Charles begins by incorporating the responses of students by repeating student answers; Dr Charles reviews students' responses and elaborates further for clarity and hence better understanding. This is vital to active participation in the construction of knowledge (Hardman & Hardman, 2017). A review of preservice teachers' responses by teacher educators is to help in mediating their learning. Reviewing clarifies areas of misunderstanding. The core of reviewing with further explanation is to refine preservice teachers' evolving understanding as educators intervene in the process (Vygotsky, 1978). This finding points to the need for a more knowledgeable other to mediate the process of appropriation of new information (Vygotsky, 1978). This review of students' responses by Dr Charles serves as an acknowledgement of students' ideas and refining the responses (Tytler & Aranda, 2015).

Category 4: TE uses PowerPoint slides to illustrate a concept.

Excerpt 4

L: So what I am trying to do here is to come up with a framework. So am trying to help you to be critical when you look at any aspect that is how do you look at the environment?

TE models critical analysis of concepts as he explains the concepts their connection and how they affect human well-being with PPts slides.

What do you find in the top left corner? What is there?

(Using slides as a mediating tool) TE uses PPts to explain a concept

Is a plant, dry plant? Now, this plant never matured to produce fruit. At the same time, we are receiving draughts and we are also receiving water and these are not easily predictable. And anyone who knows this?

If you don't have any comments, I will like you to start analysing this. Take an issue you are familiar with in your constituent area. Where is the term used by Odonoghue which states for water, energy, health, agriculture, and biodiversity? But I will also like you to think about climate change and I will also like you to think about human population, human settlement, and waste management those are the issues that I am going to test you on and examine on how you can work with those in using this

diagram. Use the diagram to identify the forces of biophysical, social, and economic issues in the environment. Use the diagram to analyse all of these.

TE uses PPts to engage the class with instructional activity

Category 4 as shown in the table 5. 4 above features 4 times in Dr Charles lecture one and once in lecture two. Dr Charles incorporates uses his PowerPoint slides to model the issues environment and their connection and how they affect human wellbeing as shown in the excerpt above. The use of PowerPoint slides offers a platform to transverse between visual representations of the physical and natural world in the lecture setting (Arneson & Offerdahl, 2018). The use of visualizations in biology is a medium to express the complex interactions of biological systems on a wide scale (Tibell & Rundgren, 2010). What is interesting in this category is that Dr Charles mediates the learning of his students and also using PowerPoint slides as additional mediating tool to bring about clarity for his students. This is important argued Vygotsky (1978) in the learning process, the use artifacts and the teacher being a more knowledgeable other play the role of mediating and building of building bridges of instruction to work with students' spontaneous knowledge as they are introduced to more formal scientific knowledge. Dr Charles in turn engages the class with an activity using a diagram on the slides. This activity was employed to engage the mind of the class about the forces of biophysical and economic issues affecting people. This activity challenges the whole class into reflecting of the happenings in their local environment.

Category 5: TE explains verbally only

Excerpt 5

L: So what I am trying to introduce to you is a tripartite relationship between three concepts. One concept is called environment another concept is called development and another concept is called education.

And inside here is what we call education for sustainable development but if you go into some institutions in the country, right I studied at Rhodes University they call it environmental education. If you go to Stellenbosch they will call it environmental education, we will get to see why these are related but not the same as why education for sustainable development and environmental education are related.

It is an interesting field and a growing field, it is not entirely new. South Africa started on it around 1989 and it is growing.

And where is environmental education required? Environmental education is required in a wide field and because we have another course which is already running right now

environmental education course is called masters in Environmental skills planning and development.

So my purpose is to introduce to you the link between life sciences education with the education of issues about environment and development that affect human well-being. **TE explains the connection between life sciences and issues of environment and development in the society**

Right, when we talk about decolonization we want to say initially what is a colony? A colony we know goes back to 1884 when some German chancellor then got everyone close to a meeting the potential colonisers and then they said Africa is a nice cake. But we don't have to fight for Germany in 1884.

Then what came after is that African countries were colonized. I am talking about African countries alone but colonization goes beyond that. Then in about 1963 countries in Africa that were colonized started removing colonisers.

And South Africa is one of the very last ones to remove the colonisers.

TE further explains the concept of decolonisation and the last African country to be liberated as South Africa.

Category 5 as shown in Table 5.4 above features 17 times in Dr Charles's lecture one and 7 times in lecture two. This suggests that the highest occurrence of verbal explanation in Dr Charles is a practice of clarification of concepts so that the internalisation of concepts will be enhanced by the classroom experience. In the excerpts shown above, Dr Charles employs explanations are supportive procedures in shaping students' understanding of science content (Aranda et al., 2020; Cian & Cook, 2018). Research suggests explanation creates opportunities to improve ideas (Sukamto, & Purwo, 2016) hence, its critical place in the learning process. Explaining concepts in a lecture setting expedites fruitful interaction (Cian & Cook, 2018). In the excerpt shown above Dr Charles started his explanation by linking his experience at Rhodes University and then proceeded to link life sciences to environment education. The class seems to be quiet however, when explaining colonizer and decolonization it sparks students' interest as they were keen to understand the discussion but not motivated by the science content for their learning. The pedagogical intent of the explanation is to facilitate the understanding of the content discussion. Explanation in the science classroom is an interactive process that may trigger the moment response in form of questioning (Geelan, 2020). The excerpt below demonstrates how Dr Charles employed the use of verbal explanation to create opportunity in his lecture.

In the excerpts shown above Dr Charles employs explanations to introduce concepts. (Aranda et al., 2020; Cian & Cook, 2018). Research suggests it creates opportunities to improve ideas (Sukamto, & Purwo, 2016) hence its critical place in the learning process. An explanation could serve as a "scaffold" to help the preservice teacher to transition to an evolving understanding of concepts they encounter in the social plane. Dr Charles employs explanations to support other instructional strategies in the course of his lectures. Research suggests that explanations and analogies as instructional strategies are supportive of students' conceptual understanding (Geelan, 2012).

Category 7: TE employs preservice teachers with mind-engaging activities

Excerpt 6

L: Do you look at it with the same eyes that you have every day or do you look at it as a life science teacher? Or do you look at anything you notice in our daily lives with a different view? And we will have a framework that you will use. And we will like to work as well on teaching methods.

TE employs preservice teachers with mind-engaging activities

And what is the relationship of the concepts with teaching methods?

TE employs preservice teachers with mind-engaging activities

What is decolonization talk to your neighbour

TE employs preservice teachers with mind-engaging activities

Yes, we look alike but we look like gorillas don't we?

TE ask mind engaging question

Video clip for the class to see.3min. (Instructional activity)

TE uses video to engage the mind of the class

And am saying what are the political factors that influence water management in your area?

TE uses a question to engage the mind of his students

and I know that when you are in town they are bylaws. And when you are in a traditional area the chief or the king determines what should happen and what does the national constitution says about water management? What does the department of the policy say about water management?

TE uses a repeated questioning to engage the mind of his students

Category 7 as shown in Table 5.4 above features 7 times in Dr Charles's lecture one and none in lecture two. Dr Charles employs his preservice teachers with a range of activities to engage their minds in form of questioning and watching a video to respond to questions. In the excerpt above from turn11, 12, 13, 33, 61 and 65 Dr Charles uses questioning to engage the minds of the whole class of his preservice teachers. Turn 61 is a video clip for the class to watch and then questioning followed. The use of video clip facilitates content engagement and retention of learnt concept since information or concept visuals exposes students to life science content. The purpose of questioning was to directly challenge his preservice teachers' cognitive function. This teacher move is what Correnti et al. (2015) called initiating move used by educators to spark discussion.

TE uses a video clip to introduce a concept

Excerpt 7

L: I downloaded this video to introduce us to the Anthropocene. Environment, development, and education are discussed here, but one thing that is embedded in the discussion is that development could be explained in two levels: during the 17th and 18th centuries, and then during the period we call industrial growth. Economic development came hand-in-hand with industrial development. It seems that somewhere in this era, there is something referred to as a colony. When we talk about development, we should be talking about industrialization, but industrialization does more than that. Consequently, we have seen a revolutionary development that has altered the entire world from where it was to where it is today. Do you remember that the geological time scale covers a large number of aeons in the past? Consequently, we have seen a revolutionary development that has altered the entire world from where it was to where it is today. Do you remember that the geological time scale covers a large number of aeons in the past?

And some of you will remember looking at a movie. There is a movie I watch when I was with my children it was called ice age. And one time the earth was cold and frozen but then eventually it started melting and got warm and that warm has continued to increase. So that warmth that we went through was a natural cycle but it was increased by industrial colony activity. So to understand that in 1972 the Stockholm conference said that development cannot continue to happen without considering the effect on the planet. So there is a relationship between economic development and the environment. Have you ever seen those two words have been put together–environment and development because development affects the environment?

TE uses a video clip to introduce the concept.

Dr Charles employs a video clip called “Anthropocene” to explain the concept of changing global environmental crisis. Dr Charles engages the students in the discussion of the video clip they observed to facilitate interaction among peers in the lecture setting. Dr Charles's use of the video clip interspaced with explanation and questioning created a platform for participation in the lecture. This opportunity was unique to Dr Charles’s lecture. This represents an opportunity for his pre-service teacher to engage with the content differently first watching the video which imprints information in their mind. Research establishes that a science curriculum that incorporates these practices is effective and increases cognitive abilities in students (NRC, 2012). The video clip paves way for students to think about the content of the video and respond to possible questions that follow the exercise. However, for this activity to translate to learning sustained participation and engagement with the video content must be achieved over period. After the video session Dr Charles encourages students to discuss amongst themselves after the video session. This allowed minimal interaction since not all students processed the information equally quality engagement for learning was not harnessed. The use of video session can promote engagement for learning when the teacher educator harnesses the social interaction resources of peers in the classroom. The use of video affords students the platform to discuss the instructional activity and reflect on their learning. The use of video clip as learning tool presents complex instructional activities to large student population with ease and hence, facilitates dynamic interaction in the social space.
TE introduces concepts creating a scenario.

Excerpt 8

L: One day I didn’t see well and then I went to a doctor and they did the blood test, they found that my blood has too much cholesterol the strategic and that was possible because of my age. My doctor said ah young man there are tendencies for obesity. TE introduces concepts creating a scenario to engage the mind of the class

50 What to do about it. Inequitable distribution of resources - walking under the shade of trees in one part of the town and not seeing any trees in another part - and even a larger vehicle cannot move on just one street. This place has no trees, the cheapest houses, and the highest population density. This place has no trees, the cheapest houses, and the highest population density. There are probably only the couple and their one or two grown children living in the 18-20 roofed houses across the street. How many resources does that entail?

TE introduces concepts creating a scenario to engage the mind of the class

By utilizing realistic scenarios Dr Charles contextualizes learning, and engages students actively in their learning (O'Neill et al., 2014). Scenarios typically involve students recalling pre-existing knowledge relevant to a given scenario, exploring 'missing knowledge', evaluating new knowledge related to the given scenario, assimilating the new knowledge, and finally configuring new learning outcomes. This finding was only demonstrated in Dr Charles's lecture orchestration in contrast to the other cases. Research supports to use of scenarios as an alternative student-centred strategy that supports multiple opportunities for learning (Snoek, 2013). Two excerpts shown above of Dr Charles's teaching scenario. The purpose of using the scenario by Dr Charles was to engage the class in the use of imagination and to facilitate student-centred interaction.

5.5 Interview with Dr Charles

I interviewed Dr Charles to better understand his practices and how they intentionally create open spaces for students to engage with life sciences concepts when they attend lectures. Questions were asked to clarify the goals of their lecture delivery to start the process.

Dr Charles is one of the teacher educators who believe strongly in the constructivist philosophy of teaching. His concern is that his students should interact in his lectures and the medium of this interaction is through talking by responding to his questions or talking with their peers in lectures or on collaborative activities (Cornelius & Herrenkohl, 2004; Vygotsky, 1978). He believes as adult learners they were exposed to live science content from metric in their first and second years. So the third-year students (preservice teachers) come to his lectures with prior knowledge of some sort and he wants to build on that.

Dr Charles as an educator is also concerned with his students' previous understanding of life science topics they were taught before his lectures. So he is interested in how these students learn new concepts or new science content (Biggs, 1993). So he engages his students with curriculum materials to capture their interest so that they will be motivated to learn. Dr Charles created opportunities to learn by facilitating interaction and creating platforms for knowledge sharing through collaboration.

5.6 Discussion of Dr Charles's lecture delivery

The results of Dr Charles's lecture orchestration yielded nine categories shown above in table four above. Category 1 and 5 ask questions without proving answers and use of verbal

explanations had a higher frequency of occurrence. This suggests that. Dr Charles's lecture delivery aims facilitate spaces of discussion and mediating understanding of content for clarity (Correnti et al., 2015). However, the last three categories were unique to Dr Charles's lectures. Dr Charles employs questioning as indicated in Category 1 without providing answers. This teaching procedure is an invitation for his students to contribute to the discussion about the topic of his teaching. These categories manifested with all the teacher educators observed to generate data. The invitation for contribution from Dr Charles is followed by probes for students' contributions. The probing session was an invitation for elaboration by Dr Charles to mediate the meaning negotiation process. These result where Dr Charles introduces concepts with questions without providing answers confirms the suggestion of Johnson and Golombek (2016) that preservice teachers need to be engaged as active participants in the learning process. Similarly, educators can also work with preservice teachers' prior learning by asking questions rather than providing an answer (De Visscher et al., 2018). Opportunities created by Dr Charles in his lectures for category one initiating discussion with questions without an answer was immediately accompanied by category two, sessions of probing for additional contribution from the whole class. However, after responses from students provide desired or correct feedback he reviews the contribution and brings clarity with detailed feedback.

Category 2 TE probes preservice teachers for elaborate meaning for clarity,

Category 3 TE reviews student's responses and gives a further explanation,

Category 4 TE uses PowerPoint slides to illustrate a concept

Category 5 manifested across the cases. Dr Charles engages the mind of his preservice teachers in a collective activity with questions that will demand preservice teachers to think together to provide descriptions of an instructional activity.

The Categories that emerge in these cases above provide evidence of engaging with preservice teachers in a large lecture space to interact collaboratively in the course of teaching and learning encounters. Research establishes that a science curriculum that incorporates these practices is effective in understanding the development of scientific knowledge, and the process of scientific research, and increases cognitive abilities in students (NRC, 2012). Research suggests how a teacher's noticing students' ideas helps facilitate sense-making (e.g., Robertson et al., 2016). The kind of tasks that students work on has the potential to change

participation and practice within a setting. The importance of selecting the right option cannot be overstated hence the critical role played by teacher educators in the selection of content in their lectures. Classroom tasks which comprise an activities system in the science classroom are vital to creating opportunities for students learning (NRC, 2015). Students will need to be offered the opportunity to learn the science content and practices aligned to the framework's vision for science learning through cognitively challenging tasks. (Tekkumru-Kisa, et al.,2015). Although instructional activities have the potential to engage students in high levels of thinking, cognitive demands on student thinking may decline without appropriate elaboration (e.g., Tekkumru-Kisa et al., 2015). Hence, my argument is that teacher educators need to elaborately probe preservice teachers with questions that demand them to engage their minds actively.

Teacher educators' knowledge and understanding of student learning gleaned from the literature suggest that the attention given to curriculum plan and development, the preparation of learning experiences and the evaluation of student learning all have a significant impact on students' approaches to learning. Vygotsky (1978) is known for emphasising the role of social and cultural context and process in development and learning. His theories on students' "Zones of Proximal Development," or the gap between what they can understand on their own and what they can understand with help. With sufficient support, a learner can be brought faster up a learning curve, and their ZPD can be continuously advanced. This idea is at the heart of concepts like "scaffolding" learning, which entails providing assistance and support. In higher education, balanced decisions about tapering support are often necessary to prevent spoon-feeding and encourage the ability to think independently (Brooks & Brooks, 1999, p. 16). For the vision of new science education reform (Bybee, 2014; Windschitl & Stroupe, 2017) to be realised, preservice teachers need to be prepared on how to engage learners in successful learning strategies as they transition to their future science classrooms.

5.6 Chapter Summary

In this chapter, I presented the analysis of teacher educators' interaction with their preservice teachers in their lecture setting as individual cases to answer my research questions in the categories that emerge from my data.

In Chapter 6, I will present details of opportunities created by two educators in their biology lectures.

CHAPTER SIX DETAILS OF OPPORTUNITIES CREATED BY TWO EDUCATORS IN THEIR BIOLOGY LECTURES

The focus of my study was to investigate how teacher educators create opportunities for learning in a lecture setting. In this chapter, I provided Ms Rose and Dr Lydia insights into the opportunities they created in their lectures. Here, lessons excerpt analysed for each from teacher educators were provided as evidence of the individual case in the study. Each case was discussed to gain an understanding of its context (Stake, 2005). A case study is undertaken to address how and why questions such as human behaviour cannot be altered by the researcher (Yin, 2003). I wanted to understand the facilitation offered by teacher educators and the ensuing interactions that followed suit leading to sustained engagement of preservice teachers with the topic of the discussion thus creating opportunities for co-construction of meaning in lectures (Mortimer & Scott, 2003). The next teacher educator I secured access to her lectures is teacher educator Ms Rose. I selected five of her lessons to report in the study and a task she assigned her students to engage in small group work. She is a seasoned teacher educator with years of teaching both life science and postgraduate students. As mentioned in chapter three Ms Rose taught five lectures on cell biology and Dr Lydia three on the biochemistry of respiration. Table 6.1 below shows an outline of the topics taught by Ms Rose

Table 6.1: Lecture topics taught by Ms Rose

Lesson	Date	Topic	Year of study	Duration/minutes	Recording
L R 1	7/2/2018	Introduction to cells	3	45	A
L R 2	10/2/2018	cell organelles	3	45	A
L R 3	26/2/2018	cell structure and function	3	45	A
L R 4	12/3/2018	Mitosis cell division	3	45	A
L R 5	16/3/2018	Mitosis review	3	45	A

6.1 Opportunities for learning that were created in Ms Rose's lectures

Category1	TE introduces concepts with questions without providing answers
Category 2	TE probes preservice teachers for elaborate meaning for clarity
Category 3	TE review the student's responses and gives further explanation
Category 4	TE uses PPts slides to illustrate a concept.
Category14	TE introduces concepts with explanations and questions without providing answers
Category 15	TE probes to check preservice teachers' understanding
Category 16	TE verbally explains concepts after repeated questioning the class without a response
Category 17`	TE introduces concepts with questions without providing answers and uses PPts illustrations
Category18-	TE review the student's response and gives further explanation and probes further

Table 6.2: below shows the frequency of occurrence of each category across the five lectures

Category	Lecture 1	Lecture 2	Lecture 3	Lecture 4	Lecture 5
Category 1	6	9	7	1	3
Category 2	2	20	10	18	41
Category 3	3	13	18	4	7
Category 4	1	1	1	7	7
Category 5	13	0	0	36	9
Category 14	0	0	2	0	0
Category 15	0	1	1	0	0
Category 16	0	0	5	0	0
Category 17	0	1	2	0	0
Category 18	0	0	3	0	0

Category1: TE introduces concepts with questions without providing answers

Excerpt 1

L: When we talk about cells what comes to your mind?

L: I am exposing that slide slightly… Is there anyone of you who has an indication as to how Robert Hooke is signified as the first person who discovered what a cell is?

L: How can we explain cell specialisation?

L: Why do we say those cells are specialised?

Category 1 is where the TE introduces concepts with questions without providing answers, has the highest occurrence in the Lecture 2 followed by lecture 3 and then Lectures 1 then Lectures 5 and 4 with the least occurrence.

Table 6.2 above illustrates the frequency of category 1 in the five lectures observed.

In this excerpt, Ms Rose introduced the topic of cell biology with open-initiating questions. However; question four and five were closed question demanding a specific answer. She did not provide an answer waiting for the student's contribution. Research suggests that Wait time by educators provides students with an opportunity to reflect on the invitation by the teacher and respond in accordance (Maroni, 2011). The essence of Ms Rose's question is to initiate discussion to engage the mind of her students. Literature suggests that teacher questioning is an invitation to elicit student ideas or elaborate on their prior knowledge (Lemke, 1990). This teacher move is referred to as the initiating move which serves to spark interaction in the ongoing flow of discourse in the classroom (Correnti et al., 2015). Ms Rose proceeded to engage the class using a PowerPoint slide to explain the concept of the cell. Excerpt two below illustrates the explanation.

TE uses PPts slides to illustrate a concept

Excerpt 2

L: Okay I can see that there is no response. Looking at the slide up there we can see that when mention is made of a cell it goes right back to ancient times if we can call it that. And looking at that diagram you can see that the coining of the word cell originated as early as around 1665 which is a lot of centuries away from where we are right now. When you get your readings you need to focus on those scientists who first discovered a cell and in their discovery of a cell they ended up discovering very distinctive things as the years went on about a cell each one listed there is listed because of the contribution they made towards what a cell is and what each one identified about a cell

L: I Am exposing that slide slightly…is there anyone of you who indicates how Robert Hooke is signified as the first person who discovered what a cell is?

L: Anyone who has heard about his discovery. What made him decide among all the living things that you see that this is a cell? Anyone who heard anything in that regard? Is it holidays that are still bombarding your mind and brains?

Robert Hooke is indicated as one of the first scientists who discovered a cell. How he discovered that cork is from a plant and cork helped in cell identification. I don't know where the cork came from but think for yourselves. Where do we normally get corks from? What is going on in your mind? We are thinking about the cork…. Right in the present day where will you normally find cork?

TE probes preservice teachers for elaborate meaning for clarity

S1: Wine bottles.

L: So am…In the present age… I hope you are not thinking about what I think you are thinking about.

L: Can I continue am mentioning a kitchen utensil that has a lid and a fitting cork? I hope that does cut your filthy minds. Robert Hooke perhaps was working with cork and you know what the consistency of a cork is like you can see is the accumulations of stuff perhaps compress to give it that solid consistency. So I imagine that particular cork that he was using was falling apart and there were splitters of that cork coming off from the original cork that he had. So out of curiosity he took those pieces and looked at them through the microscope.

L: Can we continue? Right, so there we see a system that but we know for a fact that within this organism we have many systems that work together. Systems that all originate from a cell and this system end up making a very vibrant individual or separate individuals which is an accumulation of systems which will end up making a human being where all these systems work together towards making the organism performs his function orderly. The next slide is showing the various organisation towards an organism or a human being. This blank space that you see here. Remember that this was supposed to be an introduction that you should have done on your own being able to distinguish between cell types in other words think back about first-year looking at a prokaryotic cell, eukaryotic cell. And then look at the different kinds of cells (a plant and animal cell) and at the end of this introduction you are supposed to write a test.

TE uses PPts slides to illustrate a concept.

Excerpt 2 above was taken from a teaching transcript of Ms Rose on the topic of the cell. This is an introductory lecture and she invited students' ideas early in his lecture by opening a space of interaction with open and closed questions and student one responded to her prompting. Ms Rose explores and exploits student ideas, without evaluating the ideas. However, she later

verbally explains the significance of cell study when students' contribution was not forthcoming even with her insistence with probes for contribution. Later a response was delivered from a student who responded wine bottle. Ms Rose proceeded to give an elaborate explanation with the use of PowerPoint slides. This strategy in Mortimer and Scott's categorization is referred to as a dialogic communicative approach here. Ms Rose opens an opportunity to learn in the lecture for students to voice their views on the topic. The scientific point of view is not the priority of this interaction but she tries to solicit students' views to work with their prior understanding to build new understanding (Mortimer & Scott, 2003). She then used a representation with PowerPoint slides to illustrate the concept of cells. Then she engages the class in probing and finally, there was a contribution. In the excerpt above, Ms Rose employs explanation to establish clarity for the topic of discussion (Aranda et al. 2020; Cian & Cook, 2018). This is a student-centred strategy that promotes participation and hence, facilitates the meaningful negotiation process.

Excerpt 3

Excerpt 3 shown below is from Ms Rose's second lecture on cell organelles

L: Right. Uh, can we quickly go through this uh complete this, this first set of notes? Right. Uh, we started looking at uh the organelles that are embedded in the cytoplasm, that are embedded in the cytoskeleton. And we said we have two kinds of cell organelles: the ones that are embedded, and that have their origin in membranes - in other words, membranous organelles. And then we have the second type of membrane which is referred to as uh organelles that are - did I say membranes? Ok, we have two sets of organelles: those that have their origin in membranes; in other words, they are membranous organelles. And the second type is those that have their origin in bacteria. So those are the two main types of organelles that we have within that cytoplasm. Right, now uh I would like you to list, give me a list of the cell organelles that are membranous in nature.
TE uses explanation to introduce a concept.

Excerpt 3 was from a lesson transcript of Ms Rose on the topic of cell organelles. This is an introductory lecture and she invited students' ideas early in the lecture by requesting students to give a list of cell organelles. Ms Rose's second lecture was not initiated with questioning but with an explanation. This suggests that shaping students' understanding was needed to clarify prior knowledge of science concepts from students' contributions she gleaned from the previous lecture. The scientific point of view is the priority of this interaction, Ms Rose This prepares the class for whole-class discussion and hence an invitation to participate as the

educator builds the scientific story of the content (Cian & Cook, 2018; Msimanga & Lelliott, 2012). Ms Rose engages preservice teachers with explanations for clarity; this provides the platform for active participation in the construction of knowledge (Hardman & Hardman, 2017). Literature suggests that teacher explanation provides scaffolds for student understanding (Christodoulou & Osborne, 2014; Reusser et al, 2015). Instructional explanation places demand on teacher's content knowledge and also the knowledge of students (Geelan, 2020).

In the next section, I provided the third category of finding in Ms Rose's third lecture Cell Structure and Function

Excerpt 4

L: Kabelo, can you help her out? What happens at D? How do we reach that stage and why? Why are those molecules now in ionic form? And for what purpose?

TE probes preservice teachers for elaborate meaning for clarity

Kabelo: You said, you said that the plasma membrane is selectively permeable

L: Mmm

Kabelo: Meaning that certain substances like A, B, C can be allowed to go through, and then some others cannot because of their nature

L: Right

Kabelo: So the ion, for example, if you take sodium, fluoride, or something like that before it becomes broken down to being sodium and fluoride ions and the receptors in the protein part, or the protein of the bilayer – phospholipid bilayer

L: Mmm

Kabelo: Have to sense he's coming through. And before they can enter into the first part of the layer they need to, the receptors sense that, and then something? The process occurs for those to be separated into ions.

L: Mmm

Kabelo: And then only after they're separated as you see in the future they can enter through into the basal membrane

L: Mmm

Kabelo: And?

L: Right. Are you all following?

TE probes preservice teachers to engage their mind

Class: Yes [students chuckle]

L: You said, "Mmm", but the answers couldn't come through clearly. Right. In uh D it means the bilayer - remember the bilayer is made of uh lipids. For D to pass through, to be in that ionic form means the protein part as well as that glyco uh the glucose that lies ahead uh is part of this bilayer. Should I go to the…to the next? Is there any need for me to go back to the other slide?

Category 3 TE review the student's response and gives further explanation.

As shown in Table 6.2 above, teacher educators probing for students' input featured the highest frequency in Lecture 5 and the lowest frequency of occurrence in the Lecture 1. Lectures 2, 3 and 4 have a frequency of 20, 10 and 18 respectively across the five lectures. This opportunity is the most prevalent compared to the other categories. This implies that Ms Rose persisted in probing to get the students to respond to the content of the discussion. The probing session paves way for extended interaction in the meaning-making process. Excerpt 4 was taken from Ms Rose's lecture transcript on the topic of mitotic cell organelles. Ms Rose created opportunities for learning to engage her preservice teacher with elaborative probes in form of solicitation for a contribution as shown in Excerpt 4 above. The sustained question and answer session finally ends with a review of students' responses with further explanation. The teacher moved to review the student's response (Tytler & Aranda, 2015), function to shape the student's contribution. This strategy encourages active participation in ongoing interaction. The flow of dialogic exchange where preservice teachers feel encouraged to contribute to the whole class discussion is necessary for the co-construction of knowledge (Alexander, 2014). Ms Rose's lecture delivery was interactive inviting her students' contribution as she builds the scientific story. This encourages sustained students' participation and engagement with the topic. This finding agrees with the vision of new reform in science (NRC, 2012) that stipulates shifts in instructional practices for teacher education programmes (Bybee, 2014; Windschitl & Stroupe, 2017).

Excerpt 5

L: No. Right. It means the receptors that will be on top of that bilayer, the receptors that are on top of the bilayer will detect that now this is, a complex compound that cannot just be allowed to go through the bilayer. Because it's a complex uh kind of compound, enzymes will then react with that, or enzymes will react with that compound to break it into its simplest form, to break it into those ions. And once it is in ionic form, once that compound is in its ionic form, and then will it be able to pass through that bilayer if there's a need for it intracellularly, inside that cell. So it means uh if we talk about enzymatic actions, what kind of large molecular compound is an enzyme? What are enzymes made up of? Yes?

TE review the student's response and gives further explanation

S5: Enzyme

L: Right. Enzymes are proteins, they are on the outside. Enzymes are proteins. That is why on top of that bilayer we have those globules of proteins. And some of the proteins are there to identify what molecule wants to get in or what molecule wants to go out. And of those proteins, we find that some of them are enzymes to break down complex molecules into ionic form to enable those ions to either go into the cell or be allowed out of the cell. So those four ways in which um which molecules can enter or exit uh a cell. Right. So if we look at these membrane proteins, we have spoken about, the lipid bilayer; now we look at the functions of the proteins. So remember we said uh the plasma membrane has pumps to push molecules through. It has gates, it has uh channels through which molecules go in or exit the cell. So those membrane proteins have those, they play those roles to act as channels or transporters carrying molecules from outside into the cell, or carrying molecules from inside the cell out. So they act as channels that move uh molecules especially from outside, inside. Hence we say uh those molecules that need to be assisted by proteins move in one direction. That is the role of proteins that take the role of being transporters or channels through which molecules are helped across the plasma membrane. 3

TE review student's response and gives further explanation

Table6.2 illustrates the frequency of review of students' responses by Ms Rose. The excerpt is taken from Ms Rose's lecture transcript on the topic of mitotic cell organelles. Ms Rose created opportunities for learning educators to engage her preservice teacher with elaborative probes in form of solicitation for a contribution. The sustained question and answer session finally ends with a review of students' responses with further explanation. This strategy encourages active participation in ongoing interaction. The flow of dialogic exchange where preservice teachers feel

encouraged to contribute to the whole class discussion is necessary for the co-construction of knowledge (Alexander, 2014). Ms Rose's lecture delivery was interactive inviting her students' contribution as she builds the scientific story. This encourages sustained students' participation and engagement with the topic. This finding agrees with the vision of new reform in science (NRC, 2012) that stipulates shifts in instructional practices for teacher education programmes (Bybee, 2014; Windschitl & Stroupe, 2017). Research suggests that when students are allowed to interact with scientific content in the classroom in an encounter that engaged their thinking the act is referred to as learning opportunity (McGregor & Frodsham, 2019). The teacher move of sustained question and answer session finally ends with a review of students' responses is referred to as clarifying move as argued (Tytler & Aranda, 2015) the essence of this teacher move is to shape students' inputs and hence, providing a platform for emerging understanding.

Next, I provided the opportunities created in Ms. Rose's lecture four on the topic of mitotic cell division.

Excerpt 6

L: Right, as a way of starting, what we said is uh, or before I say what the role is of uh cell division mmm cell division - and particularly mitosis - occurs in both eukaryotic and prokaryotic cells. What is the difference between those, the cell division or mitotic division in those two organisms' eukaryotic cells and prokaryotic cells? How the two kinds of mito… how would mitosis differ in the two kinds of organisms? [students moving desks?] Yes, um, you will see they have? Right, the difference of mitosis in eukaryotic cells and prokaryotic cells, how does it differ?

Yes?

TE introduces concepts with questions without providing answers

L: In eukaryotic cells, how does mitosis work or what role does mitosis play in eukaryotic cells and how does it differ from the prokaryotic cell? We already have the answer where she says the mitosis of the prokaryotic cell will yield a whole new organism through that division. My question is how is it different in the eukaryotic cells?

Yes, Kabelo?

TE probes preservice teachers for elaborate meaning for clarity

Kabelo: Well in the eukaryotic cells mitosis is significant for keeping the, one is for the fertilised egg and also is needed for growth and thereafter repair damaged tissues? Instance. So what happens generally?

L: Mmm

Kabelo: Is that the mother cell, or the eukaryotic cell, has to provide, daughter cells that become specialised to form different tissues which then become organisms to form the entire organism. So it's a stage that happens from the development after fertilisation

L: Mmm

Kabelo: Right up to growth and also in-between periods we have meiosis that comes out. So it is very significant for the development of the fertilised egg cells and then for growth and the repair of damaged tissue.

L: Right. So this will be a chromosome that is ready to undergo that division, mitosis. And we can see it's visible, it clearly shows the two chromatids bound or held together by a centromere. And uh during that mitotic division the two sister chromatids will be duplicated and separated and then they move to the poles of that cell. The two chromatids which are held by a centromere will be duplicated and each half will be pulled to the poles of that cell and be separated in that fashion. Once those chromatids are separated they are then referred to as daughter chromosomes, but in reality, they are those daughter chromatids but because they were duplicated - in other words by duplication, meaning that they are genetic, the type of genetic material that they contain is a replica of what was in the mother chromosome - they are duplicated and once they are duplicated they will move to those poles of uh the cell and at that stage, they'll be called daughter chromosomes. So uh for us to try and interpret that diagram: on, on your right-hand side you can see what is referred to as chromosomal DNA

TE uses PPts slides to illustrate a concept.

So just from that term what comes to mind? Chromosomal DNA. Mikayla?

TE probes preservice teachers for elaborate meaning for clarity

Table 6.2 illustrates the frequency of questions without answers as seen in Category 1 and Category 2 elaborate probing questions for clarity. In this fourth lecture Ms Rose in the excerpt above opens up spaces of interaction by employing questioning without answers to provide an opportunity for students to participate in the ongoing whole-class discussion (Sujarittham et al., 2016). In the lecture, Ms Rose proceeded to probe after a short waiting time when there

wasn’t response. A student responded in turn 493 however Ms. Rose did not evaluate the response. The same student asked a question to find out whether his input was right. Ms Rose encouraged him to explain further and finally Ms Rose employed PowerPoint slides to explain the concept of cell division mitosis to be precise. Questioning and probing sessions is a necessary strategy to create an opportunity to learn and practice the scientific process of knowledge generation (Cunningham & Carlsen, 2014; National Research Council, 2012). In this episode, the excerpt is taken from a lecture transcript on the topic of mitotic cell division by Teacher educator Ms Rose. Here the approach to her lecture delivery was dialogic with sustained students' participation and engagement with the topic. This is relevant to the Vygotskyan perspective on teaching and learning (Mortimer & Scott, 2003). In this teaching excerpt, Ms Rose encouraged productive participation in the unfolding flow of the whole class discussion (Cian & Cook, 2018; Msimanga & Lelliott, 2012). Research shows that when students are given many opportunities to participate in open-ended activities that involve relying on prior knowledge students share their new understandings and connections through collaborative interactions (Engle et al., 2012). Ms Rose uses the content of her PowerPoint slides to engage her preservice teachers with questions and visuals and also to explain the concept.

Next, I discuss the evidence of contrast between Ms Rose's lectures and the other cases in regard to opportunities created.

Category 14 -TE introduces concepts with explanations and questions without providing answers

Excerpt 7

L: Does that make sense? So the history and contributions that are made by that other scientist. He publishes a book actually after he has made that discovery called the Micrographia, which contains his drawings of sections of cork as seen through one of the first microscopes that he was using. He was the first person to use the term cells. Following Robert Hooke’s initial discovery about cells was this next scientific work by Anton van Leeuwenhoek. He also has a chance to work using a microscope and in his curiosity, following Robert Hooke’s discovery, he was also fascinated about this discovery and wanted to find out what is happening about these individual units called cells and what is contained within cells that is perhaps identical to microorganisms. Because I suppose being a scientist maybe he was focusing on microorganisms,

bacteria, and those minute microorganisms that we know about. But in his research, he had another discovery where he realises that the size of the cell as discovered by Robert Hooke is more or less the same as the cell he was working on about bacteria. And he went on to say even a bacterium cell is so minute and the size of that bacterium could be related to the size of the cell as discovered by Robert Hooke. And his discovery about the similarity between that discovery of a cell and his discovery about the size of a bacterium concerning the cell led him to the discovery of protozoans' altogether.

L: Why do you think he related the bacterium cell that he was working on to the cell as discovered by Robert Hooke?

TE explains verbally only please response

At the beginning of this excerpt Ms Rose was explaining the concept of cell structure as a form of a review of the previous lecture and then some minutes into the lecture she started engaging students with questions opening up spaces for dialogic interaction with her students. She asks questions that will make them engage cognitively to respond. This is a form of linkage to students' prior knowledge. This interaction is open and has the potential for meaningful learning. My argument is, therefore, that this type of interaction used by Ms Rose to scaffold learning is important. Such interaction can help grow a larger ZPD. By offering "a leading question" Vygotsky puts language at the centre of his claim on improving ZPD (Vygotsky, 1978, p. 86).

Category 15 TE probes to check preservice teachers' understanding

Ms Rose checks her students' understanding using probing questions. Ms Rose was checking students' understanding of the concepts she had taught the students in her lectures. The opening opportunity of discussion creates learning opportunities and opens deliberate spaces for conversation to happen (Aranda et al. 2020; Kubanyiova, 2012). The finding was unique to Ms Rose's lectures; however, the phrasing was different for the other cases. The finding agrees with (Weiland et al. 2014) that probing questions is a form of preparation for preservice teachers for their future roles. Also, Driver et al. (1994) and Lehesvuori et al. (2018) submit that probing questions are part of the classroom experience that a teacher provides his students.

Excerpt 8

L: Right. Are you all following?

TE probes to check preservice teachers understanding

Category 16- TE verbally explains concepts after repeated questioning the class without response

L: What is cellulose? In other words, the structure that we see in plants and the firmness that it has is because any structure that uh, or we can say a plant as we see it will be solid, it will grow upright and have its branches. But all that we see is a result of an accumulation of cell walls that made that structure solid as it is. So my question is: What structure is it that makes up that cell wall? She said, "Cellulose". What is cellulose? [brief pause]

Third years

TE introduces concepts with questions without providing answers

[Class laughs]

L: Right, cellulose will be a polysaccharide. It is a polysaccharide that is made up of glucose units. It is a polysaccharide made up of glucose monomers.

TE verbally explains concepts after repeated questioning the class without response

Windschitl, Thompson, and Braaten (2011) state, "Although many teacher preparation programmes provide conceptual tools that assist pre-service teachers to learn about teaching (e.g., broad theories about teaching, learning, or the subject matter as a discipline), these do not solve the problem of 'what to do next in the classroom' for beginning teachers" (p. 1317). This means that educators need to engage with various instructional strategies to make learning explicit to their students in a large lecture setting. Hence, Ms Rose's use of verbal explanation of concepts after repeated questioning the class without response is an effort to engage her students with these learning opportunities to arouse their cognitive curiosity to engage with the encounter provided by her lectures. The finding was unique to Ms Rose's lecture delivery.

Category 17 TE introduces concepts with questions without providing answers and uses PowerPoints illustrations

Excerpt 9

L: Right, thanks for the reminder about… thanks for the reminder about the tutorial. Right, can we continue? Right uh the diagram that is put up there is to show how the different substances can be uh or before I say so, what does that diagram represent and what does it illustrate?

TE introduces concepts with questions without providing answers and uses PPts illustrations

[Students are still talking quietly amongst themselves]

L: Mmm, what does the diagram represent? Kabelo are you the only one? The rest of the class? What does the diagram represent? Ayesha? Yes, do you want to help your friend? What does this diagram represent?

T.E introduces concepts with questions without providing answers and uses ppts illustrations

Ayesha: As it moves [speaks very softly] As it moves

L: As it's moving, what about it? What about those things?

TE probes preservice teachers for elaborate meaning for clarity

Ayesha: The egg and the molecules that can pass through the C? and also D.

L: Mmm

Ayesha: And then C is it because it needs to pass through um?

L: Mmm

Ayesha: Because it's, I think it's B passing through the?

L: Right. Mmm, she managed to tell us what happens to those different kinds of molecules that have got to pass through uh that bilayer of protein, the bilayer of lipid. F and who can explain what happens at D? What happens at D? Yes,

ah, yes tell us what happens at D? Yes, let's hear, mmm, she was saying? tell us.

TE probes with questions without providing answers and uses PPts illustrations

S4: I honestly have nothing

L: Kabelo, can you help her out? What happens at D? how do we reach that stage and why? Why are those molecules now in ionic form? And for what purpose?

TE probes preservice teachers for elaborate meaning for clarity

Kabelo: You said, you said that the plasma membrane is selectively permeable

L: Mmm

Kabelo: Meaning that certain substances like A, B, C can be allowed to go through, then some others cannot because of their nature

L: Right

Kabelo: So the ion, for example, if you take sodium, fluoride, or something like that before it becomes broken down to being the receptors in the protein part, or protein– phospholipid bilayer

L: Mmm

Kabelo: have to sense he's coming through. And before they can enter into the first part of the layer they need to, the receptors sense that, and then something? The process occurs for those to be separated into ions.

L: Mmm

Kabelo: And then only after they're separated as you see in the future they can enter through into the basal membrane

Ms Rose uses probes with questions without providing answers and uses PowerPoint illustrations is an employing another teaching strategy to create unique opportunities meaning the negotiation process. Similarly, it' helps frame the boundaries of practice being investigated '(Windschitl et al., 2011, p. 1314). This is important to the building of the teaching community for novice students enter the teaching space. This finding was demonstrated in Ms Rose's lectures in contrast to the other cases.

Category18- TE review the student's response and gives further explanation and probes further

Excerpt 10

L: Where do you find cell walls in particular, in what types of cells?

TE probes preservice teachers for elaborate meaning for clarity

Class: Plants

Class: No

L: Right. Cell walls are only found in plant cells, in fungi as well as some proteins. And the cell wall, do you find the cell wall in animal cells?

TE review the student's response and gives further explanation and probes further

L: Animal cells do not have a cell wall. So the outer lining of all animal cells will only be the plasma membrane or the cell membrane as it is known. So when we look at uh fungi and some proteins we find that the cellular wall is made of a different structure to the cellular wall that we find in plants. My question is, what is the uh the cell wall that is found in plants made up of? [Short pause] The cell walls in plants, what is it made up of? [Short pause] Grade 9 work, you don't remember a thing about it? Yes?

The excerpts above indicated Category 18 it was featured 3 times as seen in Table 6.2 above. Ms Rose reviewed student's responses and gives further explanations and probes further Teacher elaborated on her preservice teachers' contribution by requesting additional contributions and she provided an explanation and series of probes is an interaction that has the potential for meaningful learning (Abdulhamid & Venkat, 2018). Research suggests that explanations and probes and prompts encourage productive participation in the unfolding flow of the whole class discussion (Cian & Cook, 2018; Msimanga & Lelliott, 2012). As indicated earlier, interaction largely relies on how teacher educator facilitates the classroom discourse in science classrooms and also how students' inputs are responded to Correnti et al.'s (2015) this finding was unique to Ms Rose's lecture delivery.

6.2 Results of the interview with Ms Rose

In this section, I present findings from interviews with Ms Rose to gain an understanding of her practice and how she deliberately opens spaces of encounter with life sciences concepts in their lectures with a large student population. The process was initiated with questions to articulate the objectives of her lecture delivery.

Ms Rose believes in engaging her preservice teachers with questions not the transmission of facts this is evident when they talk about solving science problems or voicing their understanding of the concept of discussion. The process of mediation is in line with the social-cultural theory employed in this study (Vygotsky, 1978). Ms Rose created opportunities for her student to learn by engaging them with cues and questions that engage the student's minds and arouse their interest to learn by sharing their ideas.

Ms Rose also models practice as she employs questions to check how well her students understand the CAPS document as the CAPS document prepares them for their role as educators in their future classrooms. Ms Rose facilitates knowledge negotiating by also checking for details of students' contributions reflecting their new understanding of the concepts they encounter in the process of learning as opportunities are given to them.

6.3 Discussion of Ms Rose's lecture delivery

The results of Ms Rose's lecture delivery yielded ten categories shown above in table 6.2. Category 5 and Category 2 showed the highest frequency of occurrence in Lectures 4 and 5 respectively. This is suggestive of Ms Rose's use of verbal explanation which is Category 5 to bring clarity to the content she exposes her students to and probing questions as a teacher move that facilitates interaction (Bansal, 2018; Tytler & Aranda, 2015). However, the last five categories were unique to Ms Rose's lectures. Ms Rose employs questioning as indicated in Category 1 without providing answers. This teaching procedure is soliciting for her students to contribute to the discussion about the content of her teaching. These categories manifested across all the cases observed to generate data. The invitation for contribution from Ms Rose is followed by probes for students' ideas. The probing session was an invitation for elaboration by Ms Rose to mediate the meaning-making process. The result where Ms Rose introduces concepts with questions without providing answers agrees with the suggestion of Grooms et al. (2018) that preservice teachers need to be engaged as active participants in the learning process. Similarly, educators can also work with preservice teachers' prior understanding by asking questions rather than providing answers (Engle, 2012). When

opportunities created by Ms Rose in his lectures for category one initiating discussion with questions without an answer were immediately initiated they are followed by probes until students give a response that answers the solicitation. However, after responses from students provide desired or correct feedback Ms Rose reviews the input to bring clarity.

Category 2 The TE probes preservice teachers for elaborate meaning for clarity,

Category 3 The TE reviews the student's response and gives a further explanation,

Category four The TE uses PowerPoint slides to illustrate a concept.

Category 5 The TE uses verbal explanation only manifested across the cases.

It can be concluded that the categories that emerge above provide evidence of preservice teachers interacting collaboratively on the social plane in the course of teaching and learning encounters.

6.4 Learning opportunities were created in Dr Lydia's lectures

The next teacher educator I secured access to her lectures with is Dr Lydia. I took all three of her lessons to report in the study. She is a seasoned teacher educator with years of teaching both in life science undergraduate programmes and postgraduate students. I also assisted in these lectures as her teaching assistant.

Table 6.3: Lecture topics taught by Dr Lydia

Lesson	Date	Topic	Year of Study/duration		Recording
L , L 1	17/4/2018	Biochemistry of Respiration	3	45	A
L, L 2	20/4/2018	Aerobic Respiration	3	45	A
L, L 3	23/4/2018	Anaerobic Respiration	3	45	A

.

The teacher educators' approaches were drawn from the types of mediation they gave their preservice teachers in the course of their teaching. Interactive-Dialogic (ID) approach the teacher seeks to elicit and/or explore students' views and thus takes an open non-evaluative

posture to students' contributions. This results in candid teacher-student (T-S) dialogue. However, some student-student interactions can also be dialogic if properly facilitated by teacher educators.

Category 1 TE introduces concepts with questions without providing answers repeated questions without answering.

Category 2 TE probes preservice teachers for elaborate meaning for clarity

Category 3 TE review student's response and gives further explanation

Category 5 TE explains verbally only

Category 7 TE employs preservice teachers with mind engaging activity

Category 8 TE introduces concepts with prolonged questions session

Category 12 TE uses slides to reviews previous lectures to engage the mind of her students

Category 13 TE uses PowerPoints slides to probe for elaborate explanation

Table 6.4: The frequency of occurrence of each category across the three lectures

Category	Lecture 1	Lecture 2	Lecture 3
Category 1	1	3	0
Category 2	2	15	8
Category 3	7	11	3
Category 4	0	0	2
Category 5	0	0	2
Category 7	1	1	0
Category 8	1	0	0
Category 12	2	1	0
Category 13	1	1	0

Below I present how Dr Lydia created opportunities to learn based on the categories that emerge from data.

Category 1: 1 TE introduces concepts with questions without providing answers

As can be seen in Table 6.4 above, how Dr Lydia created opportunities to learn in lecture 1 for this category once, thrice in the second lecture and none in the third lecture. The high frequency noticed in the second lecture indicates that Dr Lydia deliberately created an opportunity for interaction by employing questions to introduce life science concepts that she was going to teach. I provide examples below. In lecture 1 which was 50 minutes long, she introduced the following concepts by use of questions: Nutrition, Photosynthesis Gases exchange and Cellular respiration. The excerpt below gives an illustration of how Dr Lydia introduced these concepts.

Excerpt 1

L: Is a nice topic of discussion right? Here are some terms concerning energy transfer. We throw them around all time and sometimes we confuse them and we need to tease them apart so that we can be able to proceed. We've taking respiration, respiration, and I am sure you saw from the short quiz you have been mugged in as to the actual processes of respiration and what happened. Which is respiration and which isn't? Is breathing in and out respiration? Is it only about what happens in the cell? When respiration does start and when does it end? When does it relate to photosynthesis? And how does all that relate to your teaching?

In this excerpt 1 from Dr Lydia's first lecture on introduction to the biochemistry of respiration she deliberately provides a window of opportunity for her students to learn by asking a question without providing an explanation or answer as shown in Table 6.4 above. This provides the class with a platform to share their ideas in the ongoing flow of discussion. Dr Lydia pauses for students to respond that period of waiting provided the class time to reflect on the question asked and contribute. However, when there was no response, Dr Lydia explains briefly how the processes of nutrition, photosynthesis, and gaseous exchange are related and probed students for an additional contribution. Cornelius and Herrenkohl (2004) argued that teachers initiate discussions with questions. Dr Lydia triggered the discussion with a closed question asking for a specific content response from the class. This teacher educator's move of initiating interaction was to help students to contribute to the flow of discussion. Research shows that wait time allows students mental incubation and hence, it facilitates learning Mahmud (2019). Below are examples of the excerpts illustrating how the lecture continued as she builds the scientific story.

Excerpt 2

L: So these are things we throw about but we want to see how they are related if they are or not in terms of what we are talking about right. So biological processes are powered by two processes, nutrition, photosynthesis gases exchange, cellular respiration, etc. we have what we call anabolic processes and catabolic processes yeah. In biology is easier to remember terms if you know what the composition of the term is for instance in biology we use ana quiet a lot. Anatomy… anabolic…… and so on.

L: What does the ana stand for there? Ana stands for something Ana stands for putting together or building up. What kinds of processes will this be then? What do you think the processes will be? The ana processes We just said ana is about building up, even going to the higher-order thinking as synthesizing, where would you place the photosynthetic processes that you just see there? Is there something being build up? Can you identify the things you are putting together? Identify the product? That is where your anabolic processes will come in and almost the flip side of it is the catabolic processes. The catabolic processes what do you think are happening there? I hear somebody said it?

S1: Yeah breakdown of substances

After student one contributes to the probing session, proceeded and explains further the details of the biological process of photosynthesis and respiration as energy transfer processes. This first category of findings from the first lecture ends with a verbal explanation by Dr Lydia. The initiating move by Dr Lydia of eliciting contributions from students in her lecture is a practice that promotes participation and student-centred interaction (Cian & Cook, 2018; McNeill & Pimentel, 2013). Thus encouraging students to take responsibility for their learning over time.

Excerpt 3

Excerpt 3 below illustrates Dr Lydia's explanation as she continues with the flow of discourse in her lecture. Dr Lydia used the analogy of building and breaking to explain the concept of photosynthesis and respiration as life processes to her students. This is to bring clarity to the students understanding and working also with their prior knowledge of building and breaking. This explanation employed by Dr Lydia was a tool to explain the natural phenomena of photosynthesis and respiration.

L: So all life depends on these two kinds of processes all of life. We are either building something or breaking up something. We want to think about photosynthesis and

respiration in terms of these two processes. Photosynthesis and respiration are energy transfer biological processes that are powered by anabolic and catabolic processes that sound complicated but it summarises everything we said so far. So your photosynthesis and respiration are biological processes that we know but we just establish now that they are involved in energy transfer in a living organism. And we are saying the way they do it is in terms of these two processes either you are building up or breaking down something to transfer energy around the living organism. This summarises something you probably know by heart by now or you are still studying to understand but you have seen in the first few weeks. So in photosynthesis, you have read about… there are processes so we say the plant through chlorophyll harnesses sunlight energy. So by the time chlorophyll is done and the process of photosynthesis is done we don't see light in the leaf we see what we test for in the lab. We don't see the light we saw starch. When that started we have just sunlight carbon dioxide and water and then we have starch so is a process that converts light energy which we are not able to use. This energy is useless to us except for vision we can't use it to drive our biological processes. It can't help us indigestion, it can't help us in thinking maybe it does something in the brain psychologist say light does something to the brain but that is a different kind of biology. You can't use it directly to drive the processes in our bodies but that is where the energy is. We need it we need to harness it capture it and change it into a form that our bodies can use and that is chemical energy in the glucose molecule which is then stored as a starch molecule. That is the key purpose of photosynthesis.

Next, I give evidence of opportunities created in Dr Lydia's second lecture. In this second lecture on the topic of respiration shown in table 4 above, Dr Lydia introduced the lecture with the question without giving an answer or explanation the same teacher's move of inviting students' input as shown in Excerpt 4. This creates an opportunity for students' contribution and hence is an invitation to actively engage with the content of discussion (Morton, 2012). Student two responded however, Dr Lydia probes further to check the student's contribution and whether the contribution is from the teaching encounter from previous lecture. Dr Lydia immediately probes with a question without of the student's contribution. This is what (Cian & Cook, 2018) referred to as the rejoinder teacher move. The essence of this -teacher-educator move is to extend the students' participation and facilitate student-centred interaction.

Excerpt 4

The excerpt below illustrates how Dr Lydia started introducing concepts in her second lectures with questions inviting students' inputs.

L: Now from Friday, what did we say is the key principle about biology topic was something that kept going back to as one of the key things you need to remember

about biology and biological processes remember? I heard yes. Does anyone remember? Does anyone want to guess?

S2: Structure and function!

L: Did you hear that you remember that from Friday?

TE introduces concepts with questions without providing answers

Now a question for you this is the equation for respiration does it look like another equation that you've seen somewhere? 1

TE introduces concepts with questions without providing answer

Someone else, you want to try? So this equation is the reverse of photosynthesis.

What do you mean by this equation is the reverse of photosynthesis? Okay, you see how it is easy to stop at what's going on here without then interrogating what exactly is happening. What does it mean that the equation is the reverse of the equation in photosynthesis?

TE introduces concepts with questions without providing an answer.

Dr Lydia proceeded to review the previous lecture employing the use of an instructional tool PowerPoint slides to engage the mind of her students as shown in Table 6.4 above falls under Category 12 of the result that emerge from data.

These results were featured in the Lecture 1 twice. and
Lecture 2, once as shown in the summary of opportunities created by Dr Lydia in her lectures but they were not in the last lectures.

The use of PowerPoint slides to engage the mind of students signifies both teacher educators and artefacts mediating function in that space. This is in agreement with Vygotsky's (1978) cultural artefacts. Dr Lydia here organised the content of her lecture to engage her students' learning of content in the second lecture as a build-up to the first lecture and also create a meaningful structure and coherence of content the students are exposed to in the lecture encounter. This aligns with Ausubel's submission that a person's existing cognitive structure is important in the process of learning new concepts. Hence, the buildup of content structured and revised by using PowerPoint slides both mediates learning and creates coherent material for learning (Ausubel, 1978).

Excerpt 5

The excerpt below illustrates the review of the previous lecture with PowerPoint slides as Dr Lydia introduced concepts of photosynthesis in her second lecture.

Category 12 TE uses slides to reviews previous lectures to engage the mind of her students

L: So keep it in mind we come back to it. Here is some of what we said on Friday we've looked at photosynthesis and we've moved on to respiration and we distinguish between cellular respiration and gaseous exchange. And looking at how they served different functions related but different functions. And often confused or used interchangeably and what we are looking at here is cellular respiration right and we also said, of course, we want to pay attention to linking structure and function all right, and then we looked at exactly what topics we are going to cover you got this on your slides

And then we moved on to photosynthesis and nutrition distinguishing the two and looking at where these terms have come from and how we can remember. Then we looked at energy and all our ideas. And we looked at energy in living systems we spoke a little about that and we looked at examples of where that energy might be seen. We looked at why living organisms need energy and we said those are some of the processes that need energy and so we looked at photosynthesis and respiration as forms of energy transfer in living systems right and then we went on to distinguish between them. We spoke about the processes that power these reactions and we said there are two kinds of processes- the anabolic and catabolic and we think about photosynthesis and processes as energy transfer biological processes that are powered by these two kinds of reaction anabolic and catabolic yeah. And then we went to a recap on photosynthesis and show how we can illustrate some of them by knowing where they have come from and what each little section means.

Excerpt 6

TE probes preservice teachers for elaborate meaning for clarity

L: The products of glycolysis yes speak up the right thing?

S2: Two molecules of pyruvate plus two molecules of ATP

Category 3 TE review the student's response and gives further explanation

L: So some energy is produce which combines the ADP which already exists in the cell with one phosphate group to make it into ATP.E so we form two molecules of ATP

by breaking down one molecule of glucose and forming two molecules of pyruvate. In terms of what goes on into glycolysis and what comes out of glycolysis. Okay, and what is the process? Then the pyruvate molecules are moved or transferred from the cytoplasm they must now cross the inner membrane and go into the matrix of the mitochondrion. And then inside the matrix of the mitochondrion, another process takes place.

The Excerpt below shows Category 3 results that emerge from data as shown in Table 6.4 above reveals the frequency of occurrence for the first lecture

Lecture 1, 7 times,

Lecture 2 11 times

Lecture 3 3 times.

The high occurrence of Category 3 occurrence in the second lecture signifies the intent of Dr Lydia to shape students' contribution which is termed the "Teacher Clarifying Move" according to (Tytler & Aranda, 2015), model of the discursive function. In the excerpt above Dr Lydia reviewed the student's response and gives further explanation reviews S2 response with further elaborate explanations.

This serves as mediating the learning process and connecting to prior knowledge (Geelan, 2020). The interaction in this excerpt was a dialogic communicative approach (Scott et al., 2006). The instructional strategy clarifies difficult concepts for the class and also mediates their learning (Aranda et al., 2020; Cian & Cook, 2018). Dr Lydia used a review of students' responses to bring clarity and also employs the PowerPoint slides to review the previous lecture to build coherence and links to content units of previous class interaction in lectures.

The excerpt below illustrates Dr Lydia's continuation of lecture two. Dr Lydia started this episode with a probing question to provide the students the opportunity to share their understanding of the topic of discussion about respiration.

The results of Category 2 from the data show

he highest frequency of occurrence of 15 in the Lecture 2 then

Lecture 3 8 times and

Lecture 1 2 times.

This reveals that the probing session recording the highest frequency of occurrence signals Dr Lydia practices to extend interaction and engage students. This opportunity created by Dr Lydia is to establish clarity of concepts taught to the students and to elaborate on their contributions. This interaction is open and has the potential for meaningful learning. Dr Lydia probes her students requesting contributions to explaining concepts for clarity and interrogating contributions from the preservice teacher for additional explanation. This extensive probing for responses promotes engagement with content and thus opens up opportunities for learning (Abdulhamid & Venkat, 2018; Msimanga & Lelliott, 2012). Research suggests that integrating more learners' ideas and dialogue is necessary for the changing classroom culture (Hofferber et al., 2016; Mitchell, 2010). The excerpt below illustrates the dialogic interaction.

L: We looked at autotrophs and heterotrophs and we said trophy means. What did we say trophy means? Yes, I heard it.

S2: Feeding

L: Okay. And we distinguish between autotrophs and heterotrophs. And we said autotrophs are what? TE probes preservice teachers for elaborate meaning for clarity

S: Self-feeding R

L: Self-feeding E but we then went into the biology of it. What did we say it means in terms of biology? What examples did we give of autotrophs? **TE probes preservice teachers for elaborate meaning for clarity**

S2: Green plants.

L: Why did we say they are autotrophs?

TE probes preservice teachers for elaborate meaning for clarity

S3: Because yes they photosynthesise and so.

L: What heterotrophs did we use as an example?

TE probes preservice teachers for elaborate meaning for clarity

S3: Yes the human organism.

L: How does that make them autotrophs? Yes, you want to continue? Who wants to finish up?

TE probes preservice teachers for further elaborate meaning for clarity

S: Yes ma'am they manufacture their food, unlike the heterotrophs.

Next, I present opportunities created by Dr Lydia in her third lecture on cellular respiration.

Excerpt 7

Category 4 TE uses PowerPoint slides to illustrate a concept.

L: And the process sitting outside the mitochondrion we said is what? You don't remember? Okay did you get it.no… chorus answer? Okay, let's take it to step by step. Okay hello. So the four stages of cellular respiration as we started last week. (Using slides as mediating tool) The key things to remember are summarized this way; the first key thing to remember is that the fuel respiration for the eukaryotic cell is glucose. The first thing to know is that the fuel for respiration is glucose. And we looked at a glucose molecule. We looking at one glucose molecule and what happened to it, how much energy is generated and where is it generated okay. The first thing to remember is what are the products of this process? The fuel is the carbon molecule the products are again yesterday in that first sentence carbon dioxide, water, and ATP which is energy but later on, you will see how it is important to know how much ATP is produced and at what stage that what the rest of the talk is about. Remember we say burning the glucose molecule will be an explosive reaction. So for the reaction not to be explosive, it has been broken down into stages. And the thing you remember is how mitochondrion is adapted in terms of its structure for the function for doing these four processes okay. So let's go on with it. The second thing we pointed out is that a lot of oxygen is required for this process.

The use of PowerPoint slides to illustrate a concept by Dr Lydia was seen in the introduction of her third lecture with an illustration of cellular respiration summary in four steps. The occurrence of this result in Table 6.4 above is twice in the Lecture 3. This connotes that Dr Lydia employs PowerPoint slides to summarise her lectures as depicted by the design of the concluding slides of her three lectures observed. Here in this excerpt, Dr Lydia engages the students with PowerPoint slides to explain the step-wise process of cellular respiration. The use of the PowerPoint slide as a tool serves to both mediate the learning of the concept and serve as a mini organizer for the whole topic(Ausubel,1977) and also provide clear visualizations of the representation of cellular respiration (Arneson & Offerdahl, 2018). This lecture is the last for Dr Lydia to present her text on PowerPoint slides as a summary. It acts as a platform for her students to process the topic's main ideas and facilitates the process of

internalization of the overall content the students encountered on all three topics (Vygotsky, 1978). The practice by Dr Lydia of providing visualizations plus representation of cellular respiration to her students is an effort to present the big picture of the topic of discussion.

Excerpt 8

Category TE explains verbally only.

L: So do you see how we are slowly building up the equation that we started with? Remember? Our reverse equation reverses to the photosynthesis one where we started with a glucose molecule and we are breaking it down now we see where the carbon dioxide comes from and water comes from and where the energy is coming from okay. So that Krebs cycle and those are the products of the Krebs cycle four ATP molecules and lots and lots of NADH remember we have broken the acetyl Co-A molecule to hydrogen molecules and that is what we take with us out of the Krebs cycle yeah. So if you were to name the products of the Krebs cycle you should be able to name those three okay? Then we move on to the electron transport chain which happens on the membranes on the cristae so as you can see at this point there is no trace of the glucose no more substance that looks like glucose by now all we have are bits of ATP bits of NADH some carbon dioxide and some water yeah so all we take to the next stage are the NADH molecule. That is what goes into the electron transport chain but this is the seat of production of most of the ATP.

L: So the first three processes that we looked at produce how much ATP? Only six but this final process produces thirty-two of them and that is where oxygen is used. As you can see probably the only place where you will see oxygen even with aerobic respiration yeah. So we never use oxygen in glycolysis we didn't use oxygen in transitional reaction we didn't use oxygen in the Krebs cycle we are only using oxygen now in the electron transport chain of chemosis, okay and that is what makes it an aerobic reaction. This is aerobic respiration because the electron transport chain process where the mass production of ATP happens requires oxygen okay. So the closing paragraph there just highlights what I've just said the process glycolysis can happen without oxygen to but the other processes require oxygen because the electron chain must use oxygen to lose up the NADHs that have been produced if there aren't any oxygen there then all the other processes before it cannot happen. After all, you cannot store NADH in the cell it needs to be broken down into little bits. So please note that there is a stage that can happen without oxygen but the other three stages cannot happen and that is what distinguishes aerobic from anaerobic respiration.

Category 5 TE explains verbally only has just two frequencies of occurrence in the Lecture 3 and no occurrence in the first two lectures. This means that Dr Lydia uses verbal explanations to develop students' understanding of science concepts over time (Geelan,

2012). The excerpt above demonstrates how Dr Lydia explains concepts verbally in her third lecture to create an opportunity for students to engage with life science concepts (Morton, 2012). Research suggests that the use of verbal explanation as an instructional strategy clarifies difficult concepts for the class and also mediates their learning (Aranda et al., 2020; Cian & Cook, 2018).

Excerpt 9

Category 7 TE employs preservice teachers with mind-engaging activity

L: Is just like when your phone is drained that means there is no more energy in the battery right? You go to do something to charge it. You need a power source of an energy and it transfers the energy into the cell until is fully charged. When is fully charged you now have the currency for your phone then you start using it. Is a very bad example but these are not the same in any way but the principle is similar. So we now for ATP using the energy from cellular respiration and then we have a high energy currency. This becomes easier when we relate it directly to a glucose molecule we can see how this happens. So we are laying the principle, especially around structure. Just pay attention to the structure and then the function becomes easier to understand. So we stored the energy in the ATP which we got from food and so when we get to where we need the energy how are we going to get it back from the ATP molecule? We break that bond and it releases that energy that was used to create it. ….. So let's relate this to the last thing we are going to do. Think about it over the weekend. Think about it over and over again try to make sense of it we will revisit it to clarify issues. TE employs preservice teachers with mind engaging activity

L: Speak to the person next to you if you can see the difference (peer Discussion) okay so what did you pick up? What other electron acceptor did you talk about in the past few weeks? You did talk about an electron accepter. Yes, I hear the whispering, remember okay. It doesn't mean something different when you hear about it in photosynthesis than it does in respiration. So when we talk about electron accepter, the substance may be different but the function is the same. Where did you see an electron accepter recently? In the light reactions of photosynthesis remember that yeah and 48 what was the name of that electron accepter? Ah ha one of them, anyone of them that you remember? TE employs preservice teachers with mind engaging activity

As can be seen in Table 6.4 above, Dr Lydia provided her preservice teachers with the opportunity to interact and make sense of concepts, engaging in activities that challenge their cognitive abilities is important as shown in the excerpts. Teaching practices (Bosman, 2015), that place students in the centre of the teaching and learning process suggest using activities to engage the minds of students. In her classes, Dr Lydia engages her preservice teachers in a

peer conversation with an activity that allows them to engage in cognitive interaction on a social plane as they interact. These activities are questions to respond to and engaging in activities that place a demand on preservice teachers' cognitive ability necessary for the 'meaning negotiation' process. This category featured in the first and the second lecture, suggests that Dr Lydia challenges her students to take ownership and responsibility for their learning. In turn, Dr Lydia started the lecture delivery by giving her students the analogy of energy using a phone battery that is fully charged. It gives energy to the phone and linked it to ATP as being the energy for cellular respiration. Finally, she explained the role of glucose in a cell. Then she instructs her students to think of how ATP releases as energy in humans. In turn, Dr Lydia instructed her students to discuss with their neighbour. This gives the students the opportunity to use their language resources to interact. This process facilitates student-centered interaction (Aranda et al., 2020). The use of analogy by Dr Lydia fortifies the internalisation of the concept that she exposes her students to in the classroom.

Excerpt 10

L: Is a nice topic of discussion right? Here are some terms in relation to energy transfer. We throw them around all time and sometimes we confuse them and we need to tease them apart so that we can be able to proceed. We've taking respiration, respiration and am sure you saw from the short quiz you have being mugged in as to the actual processes of respiration and what happened. Which is respiration and which isn't? Is breathing in and out respiration? Is it only about what happens in the cell? When respiration does starts and when does it end? When does it relate to photosynthesis? And how does all that relate to your teaching? So these are things we throw about but we want to see how they are related if they are or not in terms of what we are talking about right. So biological processes are powered by two processes, nutrition, photosynthesis gases exchange, cellular respiration etc. we have what we call anabolic processes and catabolic processes yeah. In biology is easier to remember terms if you know what the component of the term is for instance in biology we use ana quiet a lot. Anatomy… anabolic…… and so on.

In excerpt 10 above which is an introductory lecture to the biochemistry of respiration, the teacher educator Lydia opens the discussion by prolonged session of questioning soliciting students' ideas. She engaged the students with the topic under discussion being biochemistry of respiration. The interaction was dialogic; she engages the students to unveil their prior knowledge from their previous classroom exposure to content of life sciences. This serves as mediating the learning process and connecting to prior knowledge (Geelan, 2012). The interaction in this excerpt was a dialogic communicative approach (Scott et al., 2006). This finding is similar to category 1 however, it differs because Dr Lydia employed prolonged

session of question to open interactional space and provide opportunity for learning experience to students.

Excerpt 11

Category13 TE uses PowerPoints slides to probe for elaborate explanation

L: What did we say is the energy currency for a human organism? I heard it.

TE probes preservice teachers for elaborate meaning for clarity

S: ATP

L: Yes, thank you. And what is m ATP?

2TE probes preservice teachers for elaborate meaning for clarity

L: we spoke about all of this and we came to ATP. And we said a few important things about ATP the molecule okay. First of all, we said the ATP is an acronym for what?

TE probes preservice teachers for elaborate meaning for clarity

S: Adenosine triphosphate

L: Meaning? Is the adenosine? We spoke about the adenosine and we even related it to another topic that we covered in biology.

TE uses PPts slides to probe for elaborate explanation

L: Which one is the adenosine in the picture on the board okay?

TE uses PPts slides to probe for elaborate explanation

Which one is the adenosine…. adenine and ribose okay together they make the adenosine part of the ATP molecule. Yeah and the yellow blocks, what are the yellow blocks?

TE uses PPts slides to probe for the elaborate explanation of which one is the adenosine

As can be seen in Table 6.4, Dr Lydia employs probes in these excerpts taken from her second lecture to invite students' contributions as she builds the scientific story in her lecture. Finally, Dr Lydia employs the PowerPoint slides to probe for elaborate contributions for clarity from her students. This category featured in the first and the second lecture once in both with the

frequency of one but absent in lecture three. This means she employs different strategies to create opportunities for learning in the last lecture. These are opportunities she created in these lectures that is unique to her lectures in contrast to the other cases. Probing students provide the class with an opportunity to verbalise their ideas and hence encourages knowledge sharing (De Visscher et al., 2018). McGregor (2007) argued that probing preservice teachers shapes their thinking in the social community. Literature suggests teacher educators create deliberate opportunities for active participation and interaction (Avraamidou, 2016; Khoza & Nyamupangedengu, 2018). The excerpts are provided below.

6.5 Results of the interview with Dr Lydia

Dr Lydia believes the relevance of talk in science classroom to engaging her preservice teachers. Hence, she opens spaces of interaction with series of questions pausing to allow the diverse learners. Dr Lydia also believes the use of visual representation in form of diagrams on her power points lecture note to trigger discussion. Dr Lydia also employs the lecture slides as a mediational tool hence she supports the use of all resources to facilitate interaction. The is in agreement with the tenets of the sociocultural theory that guided the study (Vygotsky & Cole, 1978a). Dr Lydia created opportunities for her student to learn by questioning probes to engage the students' mind and arouse their interest to learn by sharing their ideas.

Dr Lydia also models practice as she lectures PowerPoints slides to review her previous units taught to the students. Dr Lydia facilitates knowledge negotiation by working with students' contribution and elaborating with detailed explanations.

6.6 Discussion of, Dr Lydia lecture delivery

The results of Dr Lydia's lecture delivery reveal the categories that were displayed in Table 6.4 above. Dr Lydia lectures yielded Categories 2 and 3 with a higher frequency of occurrence. These two are probing students for elaborate explanations and reviewing students' contributions for clarity. This suggests that Dr Lydia's lecture delivery was deliberately aimed at engaging students with the lecture content for a deeper understanding of the science content students encounter in the social space. Dr Lydia and employs questioning as indicated in Category 1 without providing answers. This teaching procedure is a solicitation of students' ideas about the topic of discussion in the whole class setting. This opens opportunities for students to learn science concepts. However, for this opportunity to be released as learning a concept, an additional process of probing questions for clarity has to

be employed by Dr Lydia. Hence, Dr Lydia follows this first category with repeated questioning by rephrasing the same question making the questions more explicit for students to respond this agrees with the argument of making room for students' contributions Fortus et al. (2015). This finding was visible across all cases. These findings from Dr Lydia are followed by her probing for student response. The probing to elaborate for clarity is a platform for an elaborate response from the students.

The first category of finding that emerges from analysed data, teacher educator introduces concepts with questions without providing answers corroborates the suggestion of Grooms (2018) that preservice teachers need to participate actively in the learning process. Similarly, educators can also work with preservice teachers' prior knowledge by asking questions rather than providing answers Erduran et al. (2020). The opportunities created by Dr Lydia in his lectures for Category 1 initiating discussion with questions without an answer were immediately followed by sessions of exploration for additional contribution from his students.

Dr Lydia provides detailed feedback as she receives feedback on the contribution.

Category 2 TE probes preservice teachers for elaborate meaning for clarity

Category 3 TE reviews student's responses and gives further explanation,

Category four TE uses PowerPoints slides to illustrate a concept,

Category 5 manifested across all the cases observed.

Dr Lydia in contrast to the other cases uses the power points slides both to review previous lectures to engage the mind of her students and to probe her students for elaborate explanations. These findings are in agreement with the suggestion that teaching strategies and the availability of social resources in the social space enhance the process of meaning negotiation (Kang et al., 2016; Tekkumru-Kisa et al., 2015). Next, I discussed the focus group interviews with students on their classroom encounters.

6.7 Focus group interview with Students'

Sapiso: For me what will count as success is when everyone in the group gets to understand a certain topic or concept. For me, that counts as a success.

Sapiso attributed his understanding of group work to the relevance of collaborative activity and the place of the teacher educators' reasoning in planning teacher activity for the whole class. One way for students to take on learning responsibility is to act as responsible

participants in the classroom through active participation in social interaction with others (Alexander, 2014; Vacca, 2013).

Motomo: My experience is more like hers. Working with my peer boost my confidence because they are my peers they could understand me. And I have gained a lot from them because they enhanced my ideas on some concepts and content yeah that is basically like hers.

In a constructivist framework, skills and concepts are learned in meaningful and integrated contexts rather than in isolated and hierarchical contexts. Learning develops over time as initial knowledge is revised in response to new questions and old knowledge is challenged. "The goal is deep understanding, not imitative behaviour.... We look for what students can generate, demonstrate, and exhibit rather than what they can repeat" (Brooks & Brooks, 1999, p. 16). The learning experience Motomo reveals the reliance on collaborative knowledge sharing to gain knowledge in the social space through interacting with peers.

Lerato: Okay I think working in group has being beneficial as you know we are people we bring different prior knowledge that we bring into and different experiences.

Social interaction as meaningful dialogue among students facilitated by the activities they were exposed to in the classroom makes them be socially interactive learners engaged learners (Vacca, 2013). Marshall and Rossman (2014)) contends "students learn more when they can talk to one another and be actively involved" (p. 207). This affirms the place of social interaction as vital to the learning process. Lerato submission that her peers bring different prior knowledge to group tasks reveals the relevance of prior knowledge as a resource to both educators and peers to enhance the process of knowledge sharing.

Kiend: In life science I feel coherence is important. So if you are teaching you need to start from the big ideas so the resources we are using is helpful in that manner.

Kiend experience reveals that she noticed how the teacher educator's reasoning in planning the task for the class of year three displays coherence. This means that the educator was implicitly modelling practice even as he exposes the students to instructional activity.

Karobo: With me what I have learn is that coherency is important but is a matter of whether you are teaching or learning inductively or deductively.

Karobo also notes the significance of coherence sequencing of learning material in the group task. This affirms the place of pedagogical reasoning action of professional teaching practice (Starkey, 2010).

Prisca: My experience I think it was worthwhile I think I have learned a lot working as a group. Because when we share knowledge and everybody has their own responsibility.

Prisca experience reveals the need for “teacher educators to create a learning environment in which students feel comfortable participating and develop confidence in their ability to learn and achieve high academic standards" (Bromley, 2008 p. 39). According to Brumby (1984), active participation contributes to “creating a positive classroom environment and establishing a community of learners who support one another.” This implies that the activities or tasks that educators assign to students should encourage both knowledge-sharing and active interaction.

6.6 Discussion

Although the literature suggests that higher education classrooms are not interactive spaces due to the diverse student population (Boating, 2012; Hurst et al., 2013). This study demonstrates how teacher educators created opportunities and facilitated interaction and engagement for learning with elaborative instructional strategies. The purpose of probing questions and elaborative prompts are significant triggers to the interactive process of learning with a diverse student population. According to the NRC (2012) study, science curriculum studies incorporating student-centred instructional strategies increases students' knowledge of how scientific knowledge is developed and how scientific research is conducted, as well as their cognitive abilities. Researchers have found that incorporating students' ideas can facilitate sense-making (Robertson et al., 2016).

Students' use of tasks can determine their level of participation and practice in a setting. The importance of selecting the right content for lectures can't be overstated for teacher educators. Integrating classroom tasks that comprise an activity system is essential for creating opportunities for students to learn (NRC, 2015). The Framework's vision for science learning will be met through cognitively challenging tasks that will help students learn science content and practices. In both cases, Tekkumru-Kisa et al. (2015) submits that challenging classroom task have the potential to engage students in high levels of thinking, cognitive demand of student thinking may decline without appropriate elaboration (Tekkumru-Kisa et al., 2015). Hence, my argument is that teacher educators need to elaborately probe preservice teachers with questions that demand them to engage their minds actively. It has been shown that teacher educators' knowledge and understanding of students' learning has a significant impact on how students approach learning, especially their attitudes toward curriculum planning and development, preparing learning experiences, and assessing student learning (NRC, 2015). As Vygotsky (1978) points out, social contexts and cultural contexts shape the process of development and learning. One of his theories is that students can comprehend some things

on their own, but others require support and guidance. With sufficient support, a learner can be brought faster up a learning curve and their ZPD can be continuously advanced. Assisting and supporting students is at the heart of concepts like mediation in learning. It is often necessary to make balanced decisions about tapering support in higher education to prevent spoon-feeding and encourage independent thinking (Brooks & Brooks, 1999). Preservice teachers need to receive training in engaging learners with successful learning strategies when they transition into their future science classrooms to realize the vision of new science education reform (Bybee, 2014; Windschitl & Stroupe, 2017).

I provide a summary revealing areas of increase in the range of opportunities created by teacher educators in the course of their lectures for chapters five and six.

Table 6.5 Synthesis across the four teacher educators.

Categories																		
TR. EDs	C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8	C 9	C1 0	C1 1	C1 2	C1 3	C1 4	C 1 5	C 1 6	C 1 7	C18
Mr .Jonah	√	√	√	√	√	√	√	X	X	X	X	X	X	X	X	X	X	X
Dr Charles	√	√	√	√	√	X	√	X	√	√	√	X	X	X	X	X	X	X
Ms. Rose	√	√	√	√		X	X	X	X	X	X	X	X	√	√	√	√	√
Dr Lydia	√	√	√	√	√	X	√	√	X	X	X	√	√	X	X	X	X	X

Overall the result displays four categories, that the introduction of concepts with questions without providing answers, probing preservice teachers for elaborate meaning for clarity, reviewing students' responses and giving further explanation and using the PPts slides to illustrate a concept and as a mediating tool.

These four categories were displayed across all the educators observed, teacher educators deliberately open spaces of interaction as opportunities for learning. The fact that all four educators employ questions and probes and mediating tools to trigger interaction in the social space demonstrates the vital place of teacher educators as agents that determine the extent of social interaction. Another interesting finding is that Dr Charles creates opportunities by

incorporating video clips and scenarios to engage his preservice teacher cognitive abilities in the learning process. Similarly, Dr Lydia engages her preservice teacher with elaborative probes and repeated questioning sessions without answers to created opportunities in her lectures. Also across the four teacher educators the employ a mediating tool (PPts) to support meaning negotiation. However, there was a noticeable design differences. For Mr Jonah less text on individual slides with relevant prompts, while Ms. Rose use her (PPts) to support verbal explanation in the course of her lectures. Dr Charles and Dr Lydia both employ the mediating tool to both engage the preservice teachers with activities and review of lectures to create opportunities in their lectures. Interview result suggests the reliance on elaborations probes and prompts to create opportunities for learning with large student population in lectures and four teacher educators' lectures were interactive with varying spread of communicative approaches.

6.8 Chapter Summary

In this chapter, I provided results and details of opportunities created by the two educators to answer my research questions based on the categories that emerge from data generated for this study. I also discussed the perspective of educators' practice based on the interview result. The results of opportunities created by the educators revealed areas of similarities and variation across the cases.

In the next chapter, I present the conclusion of the study with a summary of the findings and contribution of the study.

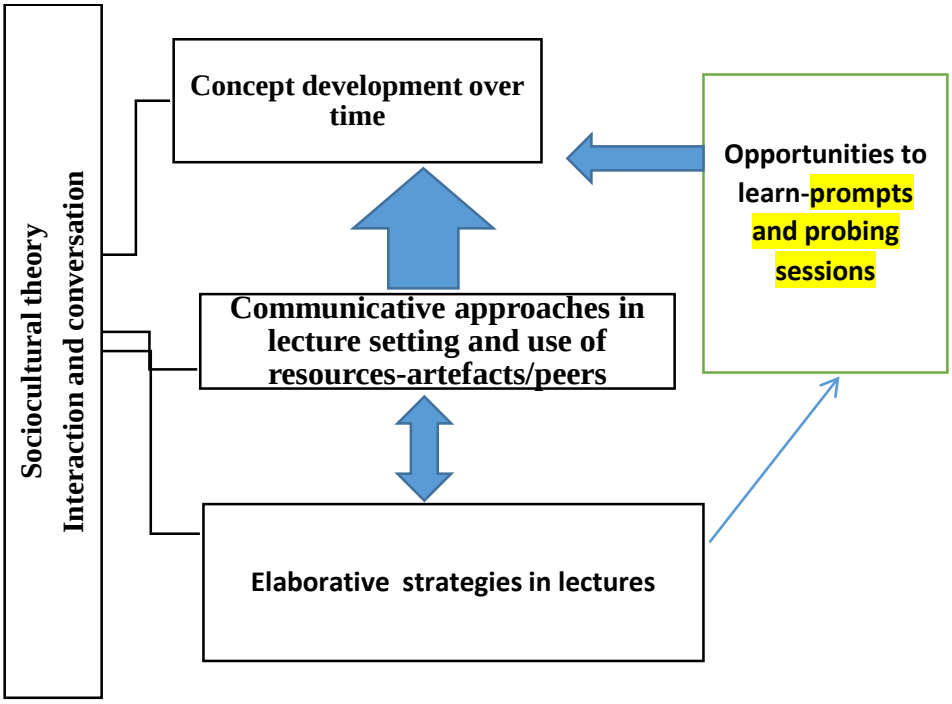
CHAPTER SEVEN: CONCLUSION AND RECOMMENDATION

7.1 Introduction

The study explored the opportunities created by four teacher educators in a teacher education programme to bring about meaningful learning. The study sought to understand the complex communicative approaches employed by teacher educators to provide preservice teachers with a platform for engagement with life science concepts in large lecture settings. To bring the study to a fruitful conclusion, I begin by restating the focus of the investigation and then moved to provide the findings that helped me to answer my research questions in the case study. I discussed the limitations of the study and possibilities for improvement in future investigations.

7.2 What was the purpose and aim of the study?

The main purpose of this study was to explore how teacher educators create opportunities for learning of preservice teachers in preparation for their exposure to their future diverse science classrooms. To answer these questions, I took a sociocultural approach to learning, identifying the role of the teacher educators in creating opportunities for learning mediation and the vital role of social interaction between teacher educators and their students. The story of this thesis is about the critical role of teacher educators in mediating the learning process by employing all resources in the social space of the science classroom with a large student population. To explain how I answered my research questions I bring here the conceptual framework. The conceptual framework gives a graphic representation of teacher educators' practice in life sciences lectures.



Modified conceptual framework

The first rectangle on the left side represents the theory that informs this study, the sociocultural theory. The teacher educator facilitates engagement with specific learning content in the course of lectures. The teacher educator employs different communicative approaches in the lecture setting this is represented by the middle rectangle. These communicative approaches could be both dialogic where the educators engage students in the interplay of meaning negotiation for learning to take place. Or the teacher educator could take an authoritative stand where the communicative approach will not be dialogic but an explanatory process necessary for the learning of science concepts. After the middle rectangle, then the third rectangle below, here teacher educators employ elaborative responses to students' contributions maintaining the classroom interaction in a whole class. Students take responsibility for their learning as teacher educators facilitate the meaning-making process with opportunities to learn through the communication that they employ to both facilitate interaction and engagement deeply with content that exposes their students. After the last rectangle, the arrow points to opportunities to learn (these opportunities are extended sessions probing questions, prompts and artefacts) then finally the first of the rectangle is concept development and this takes time. The insight from the study demonstrated that for preservice teachers to engage with science content they encounter in the classroom, the teacher educators employed different elaborative strategies and mediational tools (artefacts). The study

demonstrates that teacher educators' practice can be explored in micro context in the science classroom and fine grain analysis of discursive interactions provides the platform for the investigation in a teacher education programme. The conceptual framework was modified. The insights are discussed in 7.9 below.

Next, I will provide a summary of the study findings illustrating how my research questions were answered by a detailed analysis of the data generated.

7.3 Summary of findings

I summarise my findings according to my research questions:

How do biology teacher educators create opportunities to learn life sciences?

1. How do biology teacher educators facilitate the creation of opportunities in their lectures?
2. What is the nature of pre-service teachers' engagement with opportunities provided by educators?
3. What evidence of pre-service teacher learning can be gleaned from their engagement with learning opportunities in a lecture setting?

7.4 The occurrence of opportunities across the four educators observed

This study identified 18 ways that teacher educators use to create learning opportunities. Of these 18 ways, four manifested in all four teacher educators' teaching. These were:

1) Use of questions to introduce concepts without providing answers
2) Use of probing questions
3) Reviewing students' responses
4) An explanation and use of PowerPoint slides to illustrate a concept.

While these four approaches manifested in the four teacher educators' classes, the way they used them differed. For example, in contrast to Ms Rose and Mr Jonah, Drs. Lydia and Charles gave an extended time for the probing questions to be responded to by preservice teachers. Probing for additional responses by the educators was employed when responses were not provided by the preservice teacher or when an elaborate response to an invitation was needed for clarification. This finding points to the need to engage the preservice teachers in the process of knowledge building by creating opportunities for classroom interaction (Lemke 1990; Kubanyiova, 2012). The communicative approaches used by biology teacher educators to open spaces for interaction that provides opportunities for

preservice teachers' active interaction in lecture setting are influenced teacher educators' perspectives about teaching with a large student population (Walsh, 2006). These active (sessions of questions and responses from students) interactions are relevant for deeper engagement in learning.

Just as with the category of probing students, (Category 3 TE review student's response and gives further explanation)

also manifested differently. Ms Rose normally pauses in the cause of reviewing preservice teacher responses and also she evaluates before reviewing preservice teachers' responses. Dr Lydia will instruct the preservice to 'keep it in mind' as it will be revisited to form coherence in the process of review of responses. A review of preservice teachers' responses by teacher educators is to help in mediating their learning. As further explanation helps to provide clarity. Educators Mr Jonah and Dr Charles both review preservice teachers' responses and provide further explanations. The essence of reviewing with further explanation is to solidify preservice teachers emerging understanding as educators mediate the process of learning (Vygotsky & Cole, 1978b). This finding points to the need for a more knowledgeable other to mediate the process of appropriation of new information (Vygotsky, 1978).

Category 4: Use of PowerPoint slides to illustrate a concept manifested across the four educators observed.

However, educators vary in the use of this mediational tool to engage with preservice teachers in the interactional space in creating opportunities to learn. Ms Rose uses the content of her PowerPoint slides to engage her preservice teachers with questions and visuals and also to explain the concept. Mr Jonah limits the text in the slides and puts the structures of diagrams. He uses the text to engage preservice teachers with probes as they voice their understanding of the topic of discussion. Dr Lydia uses her PowerPoint slides to review the units of her lectures and Dr Charles uses his PowerPoint slides to model the analysis of environmental issues and their connection and how they affect human wellbeing. Even though all the educators employ PowerPoint slides in their lecture delivery usage varies in design. The three educators design the varying spread of text diagrams and probing questions to engage their preservice teachers'. The use of PowerPoint slides in lectures according to (Arneson & Offerdahl, 2018) allows biology students to navigate complex biological visualizations with a large student population. The essence of the use of PowerPoint slides by educators is to provide mediational tools to support the process of learning. Hence, PowerPoint slides are an

instructional tool that supports learning. These four categories discussed above are areas of commonalities for the categories of opportunities in teaching transcripts analysed for the four educators.

Category 5: TE explains verbally only

This finding is not common across the teaching transcripts of the educators. It manifested in Mr Jonah and Dr Charles's teaching transcripts. The use of verbal explanation was a non-interactive approach. However, the educators establish their authority as they build the scientific story in the course of their lectures. This finding provides clarity to the class discussion of content taught (Aranda et al., 2020). Educators explaining phenomena are a practice that helps to develop understanding this agrees with the new vision for science education classrooms (NRC, 2015). To teach preservice teachers with different levels of content knowledge is challenging hence verbal explanation is necessary to carry along preservice teachers with different learning styles.

Category 6: TE uses illustrations on board

This finding manifested only with Mr Jonah's teaching transcript. The use of illustration on the board allows Mr Jonah to vary his pace of lecture delivery as preservice teachers need time to assimilate new information. This allows Jonah to regulate the content to give his preservice teachers and also adjust his lecture delivery. The board could serve as a platform where preservice teachers could visualise the educator's mind. This finding points to the relevance of the board to manage a large population of students with illustrations on the board.

Category 7: TE employs preservice teachers with mind-engaging activities

This finding is visible in three educators' teaching transcripts Mr Jonah, Lydia, and Dr Charles. Mr Jonah used diagrams on his PowerPoint slides to engage the mind of his preservice teachers in a collective activity with questions that will demand preservice teachers to think together to provide solutions to the instructional activity. Lydia engages her preservice teachers in a peer discussion with mind engaging activity this allows for peer mediation in the learning process as they interact on the social plane of the science classroom. Dr Charles employs his preservice teachers with a range of activities to engage their minds. These activities are questions to respond to, video clips to watch and discuss, and finally visual prompts from his PowerPoint. Engaging in activities that place a demand on preservice

teachers' cognitive ability is necessary for preservice teachers to be exposed to productive struggle and sense-making of concepts.

Category 8: TE introduces concepts with questions without providing answers repeated questions without answering

This finding is unique to Dr Lydia's teaching transcript. Questioning is a resource for teaching and hence learning with a large population of students. Repeated questioning during her teaching without providing an answer is to open up interaction, providing an opportunity for participation, and for the educator to check her students' previous understanding. Lydia's questions demand preservice teachers to think- Which is respiration and which isn't? Is breathing in and out respiration? Is it only about what happens in the cell? When respiration does start and when does it end? When does it relate to photosynthesis? This repeated questioning was how she introduced the topic of respiration. This repeated questioning is a strategy to facilitate social interaction which is necessary for learning to happen. The pedagogical aim of repeated questioning without providing an answer is to draw preservice teachers to provide responses that might reveal their misconception or correct knowledge of the topic of discussion. Repeated questioning without providing answers is an invitation to share ideas a joint activity (Grooms et al., 2018). Clarity, sequencing, and delivery of questions are important to facilitate students' understanding of the discussion and thus leading to a quality engagement for learning.

Category 9: TE uses a video clip to introduce a concept

This finding is only manifested in Dr Charles's teaching transcripts. Employing video clips to introduce a concept engages the mind of students and the visual knowledge may be enhanced. The video presents a uniquely effective means of illustration of complex sets of classroom encounters that may be resistant to verbal representation and which in any event may be more clearly and powerfully demonstrated by 'real people in real situations than they may be by the abstraction of a teacher educator. Newton and Sorensen (2010) highlighted the capacity of video materials to 'exemplify and share good practice' in addition the study by (Mitchell, 2010) supports how video clips can be used to model practice to preservice teachers. Video again lends itself to instructional activity because of how it can capture the 'real' and the complex encounters in classrooms (Fiedler et al., 2019). This finding is a pointer

to the need for diversifying instructional approaches to facilitate engagement in the learning process.

Category 10: TE uses verbal explanation only to introduce a concept

The finding manifested uniquely with Dr Charles's teaching transcript. Employing explanation to introduce a concept the educator takes an authoritative stance to his lecture orchestration. He presents the scientific view without soliciting preservice teachers' ideas. An explanation could serve as "scaffolds" as a support to help the preservice teacher to transition to an emergent understanding of concepts they encounter in the social plane. Hence the explanation of concepts verbally is relevant to the process of teaching and learning.

Category 11: TE introduces concepts creating scenario

This finding uniquely manifested only with the teaching transcript of educator Dr Charles. Creating a scenario to introduce a concept is a deliberate strategy to stimulate the imagination of preservice teachers to think creatively about the content they are exposed to. The essence of content delivery with scenarios as narratives is to engage the minds of preservice teachers providing a platform for discussions and interactions. The use of scenarios to introduce concepts is a good teaching approach as it projects a picture in the students' cognitive structure. Preservice teachers develop images in their minds about the scenario these are vital to the content they are exposed to (Zabel & Gropengiesser, 2015). The preservice teacher listening to the scenarios will engage cognitively and hence facilitate the process of learning.

Category 12: TE uses slides to review previous lectures to engage the mind of her students

This finding is unique to Dr Lydia's teaching transcripts. The use of PowerPoint slides to review lectures help to build links between units of content to be taught and the slides serve as a mini advance organizer for preservice teacher learning (Ausubel, 1978). This finding also points to the need for coherence in sequencing lecture design. The use of PowerPoint slides compliments the need for visual knowledge of biology students (Arneson & Offerdahl, 2018). The use of text and diagrams on PowerPoint slides engages students with different learning styles. However, the design of the PowerPoint slides to capture and arouse students' interest will lead to engagement in learning.

Category 13: TE uses PowerPoint slides to probe for elaborate explanation

The use of PowerPoint slides to probe is unique to Dr Lydia's teaching transcripts. This finding points to the need for educators to develop a pedagogical practice of promoting sense-making by probing questions in the course of lecture delivery. The need for instructional improvement for mediating the learning of preservice teachers is also facilitated by the use of PowerPoint slides as a tool (Tekkumru-Kisa et al., 2015). Also, an important aspect of biology teaching is to incorporate a visual representation of phenomena to facilitate clarity for students' process of meaning-making. The use of PowerPoint slides provides a platform for students to engage in mental activity and refine their prior understanding and solidify emerging knowledge.

Category 14: TE introduces concepts with explanations and questions without providing answers

This finding is visible only in Ms Rose's teaching transcripts. The use of explanation to introduce the concept and then engage her students in sessions of the question without providing an answer is an innovative procedure of employing explanation to reduce the cognitive demand of the content the educator was enacting to her student. And she followed with questioning without providing answers, the solicitation of responses from the student population. The process allows the students to think through the explanation now that the demand of responding has been modified by explanations to get the student population to respond. This affirms the argument (Abdulhamid & Venkat, 2018) that explanation could be used in the whole class to ease the cognitive demand and shifting preservice teachers towards sense-making engagement with the content of the discussion.

Category 15: TE probes to check preservice teachers' understanding

The finding is unique to educator Ms Rose's teaching transcript, probing students to ensure that they are in tune with you in the course of your content delivery or that their silence means they are engaging with the content differently is very important. Inviting students' contribution promotes interaction that paves way for their concept learning. The productive engagement triggered by the teacher-educator probes to preservice teacher contribution provides opportunities for learning (Abdulhamid & Venkat, 2018). Teacher questioning in the social plane, on the other hand, aims to elicit student thought and encourage students to expound on their ideas (Lemke, 1990). Teacher questioning is distinguished by its adaptability, as the teacher modifies questions based on student responses to engage pupils in

higher-order thinking (Chin, 2007). However, for these probes to transition to learning of preservice teachers their responses need to reveal a new understanding.

Category 16: TE verbally explains concepts after repeated questioning the class without a response

The finding manifested in educator Ms Rose's teaching transcript, the educator after repeated questioning provides a verbal explanation. This is an effort to dispel the ambiguity of the content to the students by being responsive to their silence of not contributing to the educator's solicitation. She employed a series of probes to encourage preservice teachers to engage with the content in her lecture. When students engage with content is beyond participation and is a requirement for learning to happen (Azevedo et al., 2012). For students to engage with the content of lecture delivery is the premise of the quality of interaction facilitated by the teacher educator.

Category 17: TE introduces concepts with questions without providing answers and uses PowerPoint slides illustrations

This finding is unique to Ms Rose's teaching transcript; she introduces concepts with questions without providing answers and uses PowerPoint slides illustrations. The use of both probing questions and PowerPoint slides illustrations is an important teaching procedure. It supports the mediation of students with content by both questions and PowerPoint slides. This is in agreement with the vision of the new science education reforms (NRC, 2012). Van de Pol et al. (2010) posit that to scaffold the learning of Students to achieve desired outcomes of the use of tools (artefact) is necessary. Hence this finding points to the need to scaffold the learning process with a productive procedure to facilitate learning with a large student population.

Category18: TE review the student's response and gives further explanation and probes further

This finding manifested in Ms Rose's teaching transcript, which means that educator Ms Rose engages her students with probes after reviewing their contribution in the process of discussion. Further probing after the explanation provides the students with an opportunity to engage deeper with the content of the discussion. This type of discussion in a whole class interaction builds the process of meaning-making of the concept being taught (Scott et al.,

2006). The review of responses with further probing from the educator is to nudge the students to new understanding within the zone of proximal development (ZPD).

These are the different opportunities provided by the educators observed for this study. However, learning opportunities do not translate to learning until deep engagement is facilitated by the type of interactional probes and questioning or explanation provided by educators in their lectures.

7.5 Question two: What is the nature of pre-service teachers' engagement with opportunities provided by educators?

Students engage with content through answer sessions and peer interaction and a few instances of initiating interaction with questions for clarity. These have the potential for meaningful learning by students in a lecture setting. Sustained participation of students and engagement is evident by responsive probing and prompting employed by all the teacher educators Teacher educators purposely engaged preservice teachers with questions to facilitate interaction, but did not provide answers. The teacher educators aim to encourage the preservice teachers to engage cognitive function to respond to the invitation for shared ideas about the topic of discussion in social space. To provide the opportunity for meaningful negotiation and to work with preservice teachers' prior understanding and misconceptions teacher educators probe for their response for clarification in the ongoing social interaction. Educators needed to inquire for clarification when preservice teachers did not offer feedback. Educators all give elaborative probes to establish clarity when an incomplete response was given by preservice teachers. Teaching with a large student population, biology teacher educators use instructional strategies to open spaces for discussion that facilitate preservice teachers' active engagement in lectures (Walsh, 2006). For deeper learning, these active interactions are beneficial. However, Ms Rose normally pauses during the process of reviewing preservice teacher responses, and also she evaluates before she reviews preservice teachers' responses. Teacher educators are responsible for reviewing preservice teachers' responses to assist them in mediating their learning. Clarification is provided by further explanation. Dr Charles and educator Mr Jonah provide further explanations of preservice teachers' responses. Teacher educators are responsible for reviewing preservice teachers' responses to assist them in mediating their learning. Clarification can be obtained by providing further explanation. Teacher educators Mr Jonah and Dr Charles review their preservice teachers' responses and provide additional explanations. However, they have areas of variation as they engage their preservice teachers with different instructional activities Mr

Jonah, Dr Lydia, and Dr Charles all engage their preservice teachers with activities employing the PowerPoint slides both as tools and printed slides (worksheet). However, their contrast is that Mr Jonah used diagrams on his PowerPoint slides to engage the mind of his preservice teachers in a collective activity with questions that will demand preservice teachers to think together to provide solutions to the instructional activity. Dr Lydia engages her preservice teachers in a peer discussion with mind-engaging activity this allows for peer mediation in the learning process as they interact on the social plane of the science classroom and also review her lectures. And Dr Charles employs PowerPoint slides as tools for students to critically analyse tasks. Lydia's repeated questioning during her teaching without providing an answer is to open up interaction providing an opportunity to learn and Ms Rose uses her PowerPoint slides for illustrations and explanations. All four educators used their PowerPoint slides as teacher aid however mediational tool, however, Dr Charles has a video clip as a tool as an addition to engage his preservice teacher.

In the lectures, I observed the dialogic engagement of students with concepts of discussion largely through the opportunity given by the teacher educators as they in separate lectures facilitated, probed, and gave extended spaces for preservice teachers to respond to their questions. In this type of interaction, teacher educators open space for the distribution of conversation and allow preservice teachers to respond to their sessions of probing delaying evaluative feedback with a pause (Lemke, 1990; Lustick, 2010). This leads to sustained engagement and preservice teacher participation. This interaction creates opportunities for learning science concepts because of the multiple mediations of this interplay in the teaching and learning process. This is in line with the sociocultural theory employed in this study (Vygotsky, 1978). Hence conversation is seen as an important pedagogical tool in the classroom since all the interaction between teacher educators and their preservice teachers for negotiation of meaning is done through the agency of verbal expression and the resources in the environment (worksheets, PowerPoint slides, video clips, board). The non-interactive communicative approach is mostly full of lengthy teacher educators' explanations with short quick-paced and closed question-answer sequences (Bybee, 2014; Hardman, 2017). This type of initiation–response and feedback or evaluation between teacher educators and preservice teachers (Cooper et al., 2006), limits participation and engagement with the concepts of discussion in the teaching-learning process. Therefore, I argue that the communicative approach has the potential to create opportunities for learning science concepts, especially the dialogic interactive approach where teacher educators and their preservice teachers engage in

sustained negotiation of meanings in their context of teacher education. The provision of elaboration by teacher educators for their lectures is to engage preservice teachers' ideas in the evolving process of knowledge construction and facilitate conversation in lectures (Hardman & Hardman, 2017). Dr Lydia and Mr Jonah's introductory lectures were mostly interactive with initiative moves in form of open questions to request preservice teachers' contributions. While that Dr Charles and Ms Rose may start with explanations followed by an invitation for contribution. These elaborative responses by teacher educators support the review of preservice teachers' prior knowledge in the ongoing flow of conversation in lectures (Kubanyiova, 2012; Lehesvuori et al., 2018). According to (Alexander, 2014) creating a social interactive classroom by educators serves as a rich environment for negotiating meaning.

7.6 Question three. What evidence of pre-service teacher learning can be gleaned from their engagement with learning opportunities in a lecture setting?

Teacher educators mediate the learning of their preservice teachers and they use artefacts (PowerPoints slides) to mediate the learning of their preservice teachers. These deliberate pedagogical moves employed by educators provided a platform opportunity for both conversation and learning of scientific concepts (Abdulhamid & Venkat, 2018; Msimanga & Lelliott, 2012). In the social constructivist view, human mental development is a product of social interaction and social experience (Vygotsky, 1978). In human history, psychological tools have differed from culture to culture in their ability to translate social interaction into psychological principles. According to Vygotsky (1978), psychological tools change thinking by telling the mind what to do. The development of higher mental functions first takes place on an interpersonal level (interpsychological plane) and then on an intrapersonal level (intrapsychological plane) (Vygotsky, 1978). In direct interaction with society, cognitive structures develop in learners. (Vygotsky, 1978, p. 29) argued that "social interactions, interpersonal relations, and communication among individuals all influence learning". Through direct contact with more knowledgeable members of society, students gain knowledge as a participatory subject. Through socialization, higher mental functions develop that lead to internalization (Zimmerman, 2013). According to (Vygotsky, 1978) internalisation is a process of reconstructing what is external. The internalization process occurs in three steps (Vygotsky, 1978, p. 56).

Teacher educators teach students science concepts that must be acquired over time. Students will experience a new reality through the new concept. According to the Vygotskian

sociocultural view of effective learning of scientific concepts, students should be exposed to deliberate choices and their ability to justify and internalize concepts so that they can subsequently reason about the concepts (Vygotsky, 1934, p.279). The development of the individual in this study is due to the concepts they are exposed to in the sociocultural setting, the lecture classroom. In addition to their innate nature, scientific concepts are intentionally introduced by teacher educators to students (Merriam, 2009). Thus the school is seen as a relevant mediator of culture, not just the space for information transmission but a social context where scientific concepts and empirical evidence are shared between students and teacher educators in an accepted space of learning (Vygotsky, 1978). The use of PowerPoint modalities of wordless narrative provides chances for interaction, open and imaginative interpretation, and co-constructive meaning-making; hence the tool provides a powerful opportunity for educators to allow this intersubjective effort (Scott et al., 2006).

Sustained elaborative responses to preservice teachers' contributions through prompts and probing by teacher educators provide opportunities for learning (Abdulhamid & Venkat 2018; Kubanyiova, 2012). The "elaborative interrogation" (Dunlosky et al., 2013, p. 397) by educators is to get preservice teachers' to engage deeply with content and also to check their understanding of the ongoing meaning negotiation process (Abdulhamid & Venkat, 2018; Buma, 2018). Preservice teachers' understanding was seen in the type of feedback they gave teacher educators; it allowed them to involve themselves in meaningful interactions.

7.7 Theoretical findings

The initial conceptualization of the model for classifying opportunities to learn about teaching in the context of in-person teacher workshops by Horn et al. (2017) was adapted for this study. It was designed to categorise a free-flowing conversation range in nature and the depth of guidance given for teachers' learning. Horn's descriptors of opportunity to learn described both the content of a conversation and also how participants participate in the conversation Dancy et al. (2018a) hence I adapted it to my study to help me understand teacher educators' practice in lecture setting which is the context of my study.

Building on this work and conceptualizing opportunities to learn with a large group of students. I established an empirical relationship between the concepts of the "opportunities to learn" model and its complexities to mediate learning over time. Findings from this study suggest a somewhat different conceptualisation as shown in chapter four. Teacher educators created opportunities for learning life sciences concepts from four different topics that yielded eighteen detailed categories of fine-grained analysis valuable empirically.

My study confirmed the diverse instructional strategies used by biology teacher educators in their lectures and how they facilitate the creation of opportunities for preservice teachers to actively participate with science content despite the large lecture spaces. The study revealed some of the difficulties of a shift in negotiating between the language of science and everyday knowledge preservice teachers come to class with as my data site consists of students with diverse home language backgrounds.

My study thus is focusing on three problems. These are the nature of teacher educators' practices, two the nature of classroom interactions and how this is mediated by teacher educators through engaging preservice teachers in the interaction, and finally how both teacher educators and students generate knowledge through their interactions in all the spaces of learning and teaching

According to Wagner (1994), my study's environment is defined by the context of teacher education, the teaching educators and their students (pre-service teachers), and the topics selected for the study to generate data. As tools of teaching, PowerPoint presentations, worksheets, and models provide a basis for students' interactive interaction in whole class settings. This study confirms the literature suggests a less interactive atmosphere due to the large populations (Boating, 2012; Hurst et al., 2013). In higher education learning spaces, these interactions are how teachers and educators will engage the contextual resources. Teacher educators engage students through interactions in their classrooms as they engage their students with questions that challenge their prior understanding (Cian & Cook, 2018; Ocbian, & Pura, 2015a). Azevedo, and Sherin (2012) describe meaningful engagement as intense active engagement of participants with the discipline's science content. I then examine how teacher education have facilitated interactions over time in their classrooms.

In all the lectures I observed with the four teacher educators, there was evidence of meaningful interaction with science content taught by biology teacher educators. The Mortimer and Scott model (2003) revealed the relevance of whole-class discussions to categorise the four communicative approaches in the science classroom. The teacher educators used different communicative either to review students' ideas or to build the scientific story. Mortimer and Scott (2003) however posited that there are varying combinations of the communicative approaches for different reasons by teacher educators.

Most of the lectures were dominated by Initiate-Response-Evaluation/Feedback triads. However, all the teacher educators have examples of sustained students' contributions as

evidenced by teacher educators creating opportunities for engagement with science content. However, this engagement takes time for the teacher educators to shift through the different communicative approaches to create the balance needed for meaningful learning (Scott et al.,2006). Teacher educators' use of elaboration framework reveals this varying indication of elaborative invitations in all cases in this study. These suggest a deliberate strategy by teaching educators to place preservice teachers at the centre of the meaningful negotiating process. This suggests that teacher educators deliberately create openings for active participation and interaction (Avraamidou, 2016; Khoza & Nyamupangedengu, 2018). Thus thoughtful engagement with preservice teachers' contribution by teacher educators is beneficial as a mediational tool to encourage interactions and engagement with science content as responsive meaning-makers (Kubanyiova, 2012).

Science teaching and learning is a social activity that involves the medium of communication for accomplishment, especially in a formal setting where talk is the most common element used to exchange ideas. My argument is that the type of mediation given in the course of teaching is very important to the process of understanding concepts in science. In a lecture setting when teacher educators invite preservice with questions soliciting their ideas despite the class size, their responses will reveal their prior understanding that will serve as a platform to build new understanding together. When the type of interaction is sustained over time it will lead to deep engagement with the content of the discussion (Engle, 2012). The results of interviews with cases also indicated that although teacher educators facilitated interaction in their lecture delivery, they employ varying procedures to encourage interaction in the social plane of the classroom.

The study reveals the complex nature of engaging with preservice teachers in higher education classrooms with a large student population and how teacher educators facilitate interaction in an effect to intervene in students learning. This is a daunting exercise for educators to mediate students' understanding of science concepts using the language of science and the language of instruction. To harmonise the shifts between teaching different topics. Varied science concepts within the topics taught and different communicative approaches that will bring about meaningful learning take considerable time to achieve in higher education. This study reveals the demands placed on teacher educators to handle this in their lectures and the need to cover the required content from the curriculum for the student to have adequate preparation for their teaching role in their future diverse science classrooms.

The cognisance of all these challenges will help teacher educators and policymakers within higher education to help with planning the curriculum for the different blocks to ease the flow of instructional planning for lecturers.

7.8 Contribution of the research

In all the lectures I observed with the four teacher educators, there was evidence of meaningful engagement in all the lectures. The conceptual framework adopted and modified for the study allowed me dissect complex interactions with a large student population. OTL are provided as teacher educators employ different communicative approaches.in the lectures. The conceptual framework as a tool helped identify links between facilitation moves to create opportunities for learning, and discursive structures leading to deeper engagement with life science content. And how participation and engagement led to learning as educators employ different instructional strategies in the social plane. The conceptual framework was used as a flexible tool to explain the practices of teacher educators in the course of teaching and learning science. The Mortimer and Scott model (2003) as component opportunities to learn framework revealed the relevance of whole-class discussions to categorise the four communicative approaches in the science classroom. The teacher educators used different communicative approaches either to review students' ideas or to build the scientific story. Negotiating shifts between the different communicative approaches in the lectures generate tension due to exploration between prior knowledge and science content in lectures but evidence from the findings revealed that all teacher educators used the different communicative either to review students' ideas or to build the scientific story. Similarly, the employment of an aspect of elaboration framework as component opportunities to learn framework provided detailed features of enacting lectures in large lecture spaces in teacher education classrooms. A methodological contribution of the study adopted and modified opportunities for learning framework. The framework reveals the finer details of teacher orchestration of interaction and responsive engagement with preservice teachers offer in a higher education context and the characterization of varying possibilities of opportunities of learning in a free flowing interaction in science classrooms.

7.9 Insights from the study

All resources in the social plane are significant tools to realising OTL created

Drawing from the conceptual framework of the research to explain the type of interactions in the science classrooms All resources in the social plane are significant tools for realising the opportunities that can be created by teacher educators with a large students' population.

All four educators observed employed questions to initiate interaction in their lecture delivery. However, the waiting period employed before a response is provided by the educator is critical to the learning process as the wait time provides the students time to digest the question and give feedback. Also, the four educators observed in this study utilised verbal communication to create opportunities for learning. They extended probing questions to promote participation and extended exchange that promotes engagement with science content they encounter in the course of lecture delivery. However, the educators need strategic timing of the probing questions for engagement with science concepts to take place. Hence, I agree with Fontus et al. (2015), who posited that the timing of follow-up questions determines student engagement with content. This supports the argument of Wooldridge et al. (2014) who call for educators to use innovative instructional approaches that foster preservice teachers' development and learning. The deliberate act by the educators not to answer the question is to encourage the class to engage with the topic of discussion (Eagle, 2012).

All teacher educators create OTL however procedure of content delivery vary

The four educators observed for this study designs their lecture delivery according to their beliefs about teaching. Their beliefs are illustrated below:

To engage his students Mr Jonah designs his slides to engage his students with the concept of the topic of the discussion thus facilitating interaction in the whole class. This opens spaces for students to bring their ideas to the classroom discussion thus facilitating students to talk about content delivery. Mr Jonah facilitates interaction in his lectures by engaging preservice teachers with questions and even the design of his lecture slides provision was made for students' involvement thus less text was used to create opportunities for soliciting ideas from preservice teachers in his lecture delivery. Mr Jonah employs the use of a board to facilitate interaction hence maximizing the use of classroom recourses to enhance the process of meaningful negotiation

Dr Charles is one of the teacher educators who believe strongly in the constructivist philosophy of teaching. His concern is that his students should interact in his lectures and the medium of this interaction is through talking by responding to his questions or talking with their peers in lectures or on collaborative activities (Cornelius & Herrenkohl, 2004; Vygotsky & Cole, 1978b). He believes as adult learners they were exposed to life science content from metric and in their first and second years. So the third-year students (preservice teachers) come to his lectures with prior knowledge of some sort and he wants to build on

that. Dr Charles designs his lecture content with assumptions about what his students know and what they don't know. Dr Charles believes in the facilitation of learning, collaboration/ communities of practice discussions/interaction activist/personal agency, PCK. Dr Charles believes in humanistic approaches to interaction about how people learn. Dr Charles as an educator is also concerned with his students' previous understanding of life science topics they were taught before his lectures. So he is interested in how these students learn new concepts or new science content (Biggs, 1993). So he engages his students with curriculum materials to capture their interest so that they will be motivated to learn.

Ms Rose is concerned with her students' active participation in her lectures and her worry is that science content should not just be given to students but that they should make efforts to take responsibility by responding to her questions which will eventually reveal their grasp of the topic of discussion in a whole-class setting.

Here, the teacher educator counts her lecture session to be successful when levels of complexity of topics taught from year one of a particular concept are achieved and students display evidence of understanding of the complex nature of topics taught in lectures.

. Ms Rose believes in engaging her preservice teachers with questions not the transmission of facts. This is evident when they talk about solving science problems or voicing their understanding of the concept of discussion. The process of mediation is in line with the socio-cultural theory employed in this study (Vygotsky, 1978). At the micro-level

Dr Lydia explores the role and dynamics of classroom interaction in the teaching and learning of science, specifically how science teachers and students talk; how talk helps students make sense of science; what talk reveals about student scientific reasoning; the role of silence and language in science learning.

Elaborative strategies are necessary for deeper engagement with the content taught

Elaboration from educators is a demand for comprehensive responses given by students to their prompts and probing questions. Probing students provide the class with an opportunity to verbalize their ideas and hence encourages knowledge sharing (De Visscher et al., 2018). Probes are signals for the preservice teachers to participate in the ongoing interaction in the social plane (Cian & Cook, 2018). Teachers are asked to respond to these probes by their preservice colleagues. During the probing session, her preservice teachers are asked to think deeply to get her answers to the probing questions. The educator elaborates on the students' answers when they respond. By using this instructional strategy, students can clarify difficult concepts and mediate their learning (Aranda et al., 2020; Cian & Cook, 2018). All four educators observed for this study employed elaborative strategies to deliver their lectures. However, Mr Jonah and Dr Charles utilize probing questions to solicit elaborate explanations while Ms. Rose and Dr Lydia used prompts and probes with their PowerPoints slides for both explanation and solicitation for elaborate contributions.

Mr Jonah's teaching transcripts has this spread of frequency occurrence for probing question across his five lectures from first to the fifth lecture respectively 13, 15, 11,18,3. Dr Charles's lecture 1 is the place where probing questions were recorded with the frequency of occurrence of 7. In Ms Rose five lectures probing sessions were recorded from 2, 20, 10.18 and 41 across her five lectures. The highest occurrence in her fifth and last lecture was due to her quest to check students understanding as she rounds up her lecture delivery. Dr Lydia's lecture delivery featured probing sessions across the three lectures with the frequency of 2, 15 and 8.

Artefacts support the mediation process

Mediation from sociocultural perspectives as argued by (Kozulin, 2005; Vygotsky, 1978) can be facilitated by artefacts and hence impacts influence the learning of a child. Parents, teachers and peers and the cultural community determine the type of interaction that happens between the learner and his social environment. Cognition can be enhanced by incorporating artefacts into instructional practice. Mediation has different facets one human and other facet. Human influence in the mediation of a student's learning as argued by Vygotsky's sociocultural theory is that a psychological function appears twice on an actual interaction in the social plane as well as an internal one. Hence, the activities students encounter in the social plane of the classroom orchestrated by teacher educators trigger the internalization of psychological and mental functions. Thus, the act of assistance by teacher educators at the unset of instructional delivery is the assistance to appropriate the science content they are exposed to

over a period of time. Vygotsky's concept of the ZPD here means that the child's ZPD can be stretched or expanded by the support of the teacher educator. This is provided the child is able to perform a task as an instructional activity beyond his actual capacity. Lantolf and Thorne (2006) argued that the type of support /mediation is seen as a modelling in a strategic moment in a science classroom

The educator could also engage his students with mind-engaging activities that will facilitate cognitive restructuring. Teacher-educator mediational strategies could be varied to accommodate the different levels of learners' abilities with a large group of diverse students. Hence, Rogoff (1995) posited that mediation strategies could be grouped into three: apprenticeship, guided participation and appropriation.

The first apprenticeship gives a model of interacting in a community and this mediates the learners' learning process in the presence of a more knowledgeable adult. Guided participation involves the interpersonal feature of joint activity in the classroom, while appropriation involves an individual learner's internalisation of the encounter as they are mediated by instructional task activities.

The four educators provided both human and symbolic mediation by the use of the English language to lecture their students facilitating the meaning negotiation process and artefacts. Dr Lydia's lecture orchestration with the utilization of probing sessions was a platform to link her students' prior knowledge and build coherent lecture sequences as Dr Lydia employ's PowerPoint slides to raise the probing questions and review her previous lectures. However, educators vary in the use of this mediational tool to engage with preservice teachers in the interactional space in creating opportunities to learn. Ms Rose uses the content of her PowerPoint slides to engage her preservice teachers with questions and visuals and also to explain the concept. Mr Jonah limits the text in the slides and puts the structures of diagrams. He uses the text to engage preservice teachers with probes as they voice their understanding of the topic of discussion. Dr Lydia uses her PowerPoint slides to review the units of her lectures and Dr Charles employs his PowerPoint slides to model practice. (Arneson & Offerdahl, 2018) argued that PowerPoint slides are a tool that supports learning.

7.10 Limitations of the study and Recommendation

Although I have employed all measures possible through the use of ethical procedures to avoid any form of bias in this study, I could not dismiss potential prejudices that emanated from me as the researcher and the research participants due to inevitable behaviour. And like

any other qualitative study, an investigation of higher education classrooms using qualitative approaches is prone to some probable limitations.

Details of opportunities encounter in the learning settings and the analysis of their progressive natures can further inform sociocultural theory and methodological lens in research but are also not without limitations. My study data were collected in a single context (teacher education programme) and hence conclusions are constrained to that sample. From a theoretical perspective, further corroboration studies must be conducted to confirm our inferences of opportunities in lecture settings (Vosniadou et al., 2008).
Another limitation is concerned with sampling and the number of participants. My research participants were four teacher educators and their preservice teachers in a University setting. My focus on these four teacher educators limits the generalisation of findings. Therefore, generalisation in this regard would be inappropriate.

The study was based on a case study and it was qualitative. Although the findings provided an understanding of teacher educators' perspective and their pedagogical practices and how they facilitate opportunities to learn as they prepare preservice teachers in a single University in Gauteng findings are limited to the context. The lessons observed were limited in number due to the time frame of the study. A more extended observation would have provided more data to get a deep understanding of teacher educators' preparation of preservice teachers using talk as a tool for their learning. However, the findings can provide clues to what is required when embarking on a similar endeavour in a similar context in the future. Similarly, my interpretations of findings may not be devoid of prejudices and biases owing to my knowledge, experiences, values, and beliefs (Creswell, 2014). Similarly, the views of the research participants may be subjective as a result of their context, values, knowledge, and past experiences too.

Lastly, my presence in the classroom could have affected how preservice teachers engage with each other. This may be due to preservice teachers' attempts to 'please' the researcher. On the other hand, the teacher educators were deliberately chosen to observe their lectures to help me obtain rich data for successful analysis. Thus, if the study was to be repeated with the same teacher educators, it may yield different results because this is a qualitative study. Qualitative interpretations are influenced by the interpreter and contextual factors (Creswell, 2014).

7.11 Recommendations for teaching and learning

Additional research is required to appreciate more about the happenings in science learning and communication with a large student population in lectures. This research - along with other case studies in other science classes contributes to the understanding of the diversity of science class practices and the complexities involved. Future studies conducted in another context might reveal different patterns or similar themes in their findings. The effectiveness of learning opportunities could be further explored in future research. The influence of culture on learning opportunities could be explored further by studying how it influences the teaching of life sciences. Padlet as a learning tool should be incorporated to improve the quality of interaction and engagement with tasks in classrooms. Padlet software could help students improve their learning by intensifying engagement in activities in the classrooms. The software supports many features and allows students to work in their own space for individual and group tasks. Students will be collaborators for specific tasks and by doing this; the tasks given can be more manageable and less stressful for them. Further study could investigate how second languages influence opportunities provided to students' preferences for learning styles in science.

7.12 Conclusion

This study reported in this thesis draws on data from four teacher educators in one University teaching biology to preservice teachers in teacher education. The claim that active participation and interaction are lacking in higher education science classrooms was challenged by the elaborative probes and prompts that facilitated productive interaction and participation of students in a class with a large population. Using a hybrid framework, a combination of elaboration framework (Abdulhamid & Venkat, 2018) and opportunity to learn model (Horn et al., 2017) illustrated the opportunities that were created by the four teacher educators facilitating meaningful interaction in the social space of the classroom. Data for the study suggests that for opportunities of learning to translate into internalisation of science concepts active participation and deeper engagement with science content is necessary. Hence the critical role of the teacher educator is vital in the process of meaning-making through mediation and scaffolding the teacher educators provide as supporting structure in the internalisation of science concepts. This is the final findings chapter and the last chapter of my study. I brought a summary of my findings explaining how the data generated helped me to answer my three research questions and enumerating the limitations of the study in the context I generated my data. To conclude this piece of work, I want to

submit that I have moved and learned so much as I engaged both with my participants and the journey of the study.

Self-reflection

The research journey has impacted my development as a science educator and researcher. Teacher educators in education context better. I realised in the process of my journey that the challenges of teacher educators with diverse student populations are knowledge sharing strategies through interaction in the classroom and the strategic deliberate opportunities they can provide for students learning. Higher education and its practice have been the focus of my study. Observing the educators in the process of teaching and learning to generate data and the analysis of their practice revealed the challenges of engaging a large population of students with a multiethnic background. The critical role played by teacher educators in mediating learning and helping students to cross borders of cultures of their home language to engage with life sciences concepts was commendable for me. I was actively involved with curriculum updates in my school from 2011 to 2015 back in Nigeria. The quest to understand how to negotiate the transition as they engage in conversation to learn both their home language and the language of science with students from diverse populations led me to enrol for my doctoral study with the University of the Witwatersrand to develop my knowledge of the teacher As a researcher my journey opened me the possibilities of learning how to use different lenses or models to make sense of classroom data, how to operationalize what type of interaction happens in the classroom community and the role of teacher educators mediating access and growth of students into being members not at the borders but being full-fledged members of the teaching community.

As a tutor and lecturer back in Nigeria reflecting on my journey of learning and selecting my study site, the selection of the model of data analysis (opportunity for learning model) and modifying it to fit my unique context to understand the complex interaction in the process of knowledge, I employed thematic analysis approach to categorise the themes emerging from the data. This engagement helped me to notice the range of teacher educators' solicitation for students' contributions and how they work with the contributions to mediate the learning process. Finally, as I worked closely with my data I could understand how different responses of educators in form of questioning probes and explanations can change the interactional space. I believed this study demonstrates the range of possibilities and potential that resides in a teaching space due to community interaction.

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APPENDICES

APPENDIX A: ETHICS APPROVAL LETTER



Wits School of Education

WITS UNIVERSITY

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

21 April 2017

Student Number: 1129121

Protocol Number: 2017ECE004D

Dear Naomi Thomas

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:

Biology laboratory work in pre-service teacher education: the potential for argumentation as a learning tool

The committee recently met and I am pleased to inform you that **clearance was granted. However,** there were a few small issues which the committee would appreciate you attending to before embarking on your research.

The following comments were made:

- The discussion on how this research fits in with the larger project is still not clear.
- 2.1: Photograph tick is still not done.

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,

M Mabeta

Wits School of Education

011 717-3416

Co Supervisor: Dr Audrey Molnar

APPENDIX B: SUPPORT LETTER FROM SUPERVISOR

School of Education
University of the Witwatersrand
Johannesburg, South Africa

3 May 2017

Dear Prof Brodie

Re: Support for Naomi Thomas request to conduct research in the WSOE

In write in support of my PhD student Naomi Thomas request to conduct her research in the WSOE. Her study is entitled "Biology laboratory work in pre-service teacher education: the potential for argumentation as a learning tool". Her research is focusing on teacher learning of inquiry practices during laboratory work.

Naomi will use argumentation as both the theory and analytic tool in examining verbal and written discussions in LSIIIA lectures and laboratory sessions. She is requesting to conduct the research with Life Sciences student teachers in WSOE, in particular the LSIIIA group.

Data will be collected through video and audio recordings of classroom interaction both in the whole class lectures where I use argumentation as a teaching strategy and in small group discussions in subsequent laboratory lessons.

Naomi has obtained WSOE Ethics clearance, protocol number 2017ECE004D – letter attached. I have discussed with her the requirements for working with our own students in the School and I will be in attendance during all the sessions when she is collecting data. She intends to collect some data in the remaining weeks of Block 2 and then again in Block 4.

I thank you.

Sincerely

Dr Audrey Msimanga

(Supervisor)

APPENDIX C: APPROVAL LETTER TO ACCESS WSOE LECTURES

Approved

Please see guidelines attached for working with SoE students.

School of Education

University of the Witwatersrand

Johannesburg, South Africa

Wits school of Education

27 St Andrews Road

Parktown, 2193

25 April, 2017

Dear Professor Brodie

Request for permission to conduct research in the WSOE

My name is Naomi Thomas. I am a PhD student in the School of Education at the University of the Witwatersrand. My PhD study is based on the topic: **Biology laboratory work in pre-service teacher education: the potential for argumentation as a learning tool.**

The study will to explore student teacher learning in laboratory setting using argumentation as a tool for learning. The study will explore development and use of argumentation practices by pre-service teachers during the course of their practical lessons in a teacher education programme. The principal aim of the study is to explore how pre-service teachers use argumentation skills learnt from their theory lessons as learning tool during their practical lessons.

To understand the perceptions of pre-service teachers about the role of argumentation in practical lessons. To determine how pre-service teachers apply argumentation as a teaching strategy for delivery of practical lessons. To ascertain the evidence of teacher learning after engaging with argumentation in the classroom. To do these I will observe a more experience senior lecturer teaching using argumentation or classroom talk and how pre-service teachers engage in a social interaction. And I will follow up pre-service teachers to see how the display their learning in a tutorial presentation in a practical class. The lesson will be audio/video taped to capture incidences that may not be captured in my field notes. There will be focus group interview with pre-service teachers. The study will benefit the participating pre-service teachers as they acquire argumentation skills which have been shown to enhance science learning.

In all of this, I will work with the basic principles of voluntary participation, ensuring Confidentiality and anonymity of participants. I will seek the students' informed consent and only the volunteering students will be included in the video recording. I realise that those who do not volunteer are entitled to being taught as fairly and thoroughly and will not be disadvantaged in any way during the teaching and in assessment. Therefore I ask for permission to conduct the study in the school of education.

APPENDIX D :LEARNER CONSENT FORM

Please fill in the reply slip below if you agree to participate in my study called: **Biology laboratory work in pre-service teacher education: the potential for argumentation as a learning tool**.

My name is: Naomi Thomas

Circle one

Permission to observe you in class

I agree to be observed in class. **YES/NO**

Permission to be audiotaped

I agree to be audiotaped during the interview or observation lesson **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 for questionnaire

I agree to fill in a question and answer sheet or write a test for this study.

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 the completion of my project.

I ----------Consent to Participate in the study that will be conducted by Naomi Thomas of the University of Witwatersrand for her research on argumentation practices in biology classrooms. I realize that no foreseeable negative consequences will result from my participation in the study, and the study will be conducted to improve teacher education in our university. I permit the material to be used for research and teaching only. I will participate voluntarily and understand that I may withdraw from the study at any time.

Learner Consent Form for life science classroom observation

I_____ consent to the researcher observing my life science lessons and field notes being made during observation. I also understand I have a right to review these field notes before analysis if I so choose. Everything I say will be kept confidential by the researcher. Will only be identified by a pseudonym in the transcript.

Name ---------- Signature---------- Date

Audio, Video recording.

I further consent to the audio-recordings of the focus group discussion to be made. I also understand I have a right to review the transcripts that will be made before analysis if I so choose. I can delete or amend any material or retract or revise ant of my remarks. Everything I say will be kept confidential by the researcher.I will only be identified as a

pseudonym in the transcript. Besides, any person I refer to in the discussion will be kept confidential.

Name ---------- Signature---------- Date

Video recording: I do/I do not consent (please delete whichever is not applicable) to the teaching intervention in your class which serves to support my field notes. As with the field notes, these will be kept Information sheet confidential.

Name---------- Signature---------- Date

APPENDIX E: INTERVIEW QUESTIONS

RQ TO BE ANSWERED	DATA REQUIRED TEACHER EDUCATORS	INTERVIEW QUESTION TO ELICIT THIS DATA	FOLLOW UP QUESTION OR PROBE
			Example of follow up questions or probe 1
How do teacher educators facilitate interaction in their science classrooms?	To establish the purpose of lecture design as it relates to the topic	How do you use your lecture slides in your lecture hall?	I don't understand please repeat, okay and then

	To establish how the slide is used as a tool to facilitate preservice teachers engagement and participation in the lecture	What are the ideas of teaching and/or learning entrenched in your Slide designs?	oh, yes and then
What is the nature of pre-service teachers' engagement during classroom interactions?	To establish how teacher educators can facilitate the process of concept learning Probing students' views and understanding	What would count as evidence that the lecture was successful for the topic of discussion?	yes okay please repeat you a statement
	PRESERVICE TEACHERS To establish how preservice teachers engage in their assigned task	What has the experience of discussing in [this task/assignment] been like for you as a student?	please tell me your thought oh, okay
	To establish how preservice teachers Identify learning goals in their task	How would you know if your result or discussion during the task execution process was successful?	Did you? okay and then are you sure
	To establish that the purpose of their assigned task was achieved	What were the key elements of this task and the way it was structured that helped or hindered your learning?	Are you okay? go on yes and then tell me

APPENDIX F: INTERVIEW TRANSCRIPTS OF TEACHER EDUCATORS.

ONE ON ONE INTERVIEW WITH MR JONAH

The researcher: Good morning I just want to get your perspective s about your lecture slides and how you facilitate interaction while you are teaching population ecology (life science iii). Because I believe no matter what I observed that is my own perspective so I decided let me have this interview with you to get your own opinion feel free to be plain with me because you know I am collecting data. I don't know do I need to discuss the research questions?

Mr Jonah: No

The researcher: okay so the first question I want to ask is how to you use your slides in the lecture hall to facilitate interactions in the class?

Mr Jonah: First for my lectures I design the PowerPoint slides in sequence of my teaching units. Normally in biology we say is about relating the structure and function. So what I do is I limit the text in the slides and I put the structures of diagrams but is not only that it also includes how I sequenced the diagram and the text. So let's say I am talking about the concept of ATP or let me just say a concept of a lung and I want to explain the function of the lung. I will put the structure of a lung **(use of visuals on slides)** and engage students with questioning asking them what do you see the structure looking like (**use questions relating to projected images to engage students)** what are some of the things you can see from the structure and they will tell me use questions relating to projected images to engage students. Then I will proceed to ask them why do you think the Lung is like this here? (**Use questions relating to projected images to engage students).** Then we will have a discussion around those Engages students in discussion So on the slide I will only have that structure and nothing else so we have a discussion and we continue. In the next slides I will have key points of the information that I want to get. **(Use of visuals on slides)** So they don't first see the text but the structure then the text and then that helps us to engage for key points before and then I consolidate the discussion.

The researcher: okay as you are preparing preservice teachers what ideas do have normally in your slides about teaching and learning.

Mr Jonah: I normally don't put **anything on my slides about teaching** I only put things about the **content that** I am teaching, but as I am teaching I consciously think about the messages that I portray to them about in terms of the **approaches** or what am doing in front of them. SO when I **interact** with them and respond to their questions I will think of what will they gain in terms of teaching from what am doing although I don't explicit state that, this is how you can teach this topic, because I believe that is more of the method class agenda. So if I have the **opportunity** to teach both the **content and method** at the same time will explicitly make reference to the content am teaching in the content class, although I do that in **the content class** but I do it **implicitly consciously thinking** about that. And in the methods class I will make reference to messages about teaching and then I need them together putting the topic. So I will say remember when we do this, I did this or we did this. That is a very good way of showing the links in teaching something like that.

The researcher: what will you count as evidence that your lecture was successful for the topic you are engaging with?

Mr Jonah: I see evidence at different levels and according to **different teaching formats of content delivery (teaching strategy).** So I would want to see **evidence within** a lecture, evidence within a tutorial and evidence within a practical evidence of learning if that is what you are asking for. **In between lectures in terms of the continuity for evidence** will be for them (students) to see the **continuity and coherence or link making (building on prior knowledge)** of the concepts. Apart of them writing test and submitting something for summative assessment. That is one way of looking at evidence for me. Another way of looking at evidence for the success of my lectures will be the **questions I ask them in the lectures (OTL)**. Going back to the question you asked **about facilitating interactions, in every slide(OTL)** I put question that I want them to discuss. Or within the slide I will say according to the graph the **population rises then I will ask a question why**? And then we will **discuss that is also evidence of how to facilitate interaction**. IF they are unable to answer the question then the concept I have being explaining I haven't been doing it well. That is not about them answering the questions in the correct manner but looking at their level of **understanding or their level of engagement with the question** (integration). How do they approach the question that I asked them and what content do they draw from to answer the question? For example, I **would ask why survival ship curves shade like that; concept of prey population** is etc. so linking the concepts from the previous lesson and the coherence for me serve as evidence for learning.

The researcher: what ideas do you fit in the task you give your students in tutorials or lab work?

Mr Jonah: it **depends on the context or the aim of knowledge (content)** I want them to get. I don't set questions of what or list this are things we do in the lecture and these are things they can read but **I give them questions that depicts a scenario** the question of why, to what extent, application questions are the ones I **engage students with so that it will be very beneficial to them in the tutorials in terms of engaging in, otherwise it** will not be beneficial for them if they are **answering what questions).** How do I set questions to be beneficial to them as preservice teachers? The other thing is relevance of the question and relevance in terms of like **every day like population ecology is evident in….** is a **topic(content**) that is out there and I must admit that is something that I have not being able to do quiet extensively. And again relevant in terms of them (preservice) teachers how do I set the questions such that they think of the questions and the answers as beneficial to them since they are going to be teachers (use of **questions as opportunities for learning**). For me to do that I need to think of **their content and the task that I give them, for example I give them simulations** and of the **different fluctuates based on the populations and how the populations interactions(content**). And the reasons for me give them that were something they could use when they go to school. So there is no point in **giving them something although sometimes** I did give them something they cannot use in schools. I am not talking in terms of knowledge, obviously in terms of **knowledge they need to have a very deep understanding of the topic (learning)**. Hence I give them a little bit more of what is being done in school of the task. Not the content of the task but the **form and structure of the task**

will speak to what they can know). The content will be deep but the task itself- what I want them to do.

Me: Okay thank you for time.

Interview transcript 8/10/2018 Dr Charles: I need your perspectives about how you facilitate interactions with life science three students.

Dr Charles: Am …… but I think the first concern is what my teaching philosophy is? What makes me teach the way that I do? **I believe in more humanistic approaches to education.** I believe in learners bringing in knowledge which means I have a strong interest in constructivist approaches and then developing them from there through the interactions in the classroom (lecture halls**). I believe that learners bring in their own knowledge to class**. And these are learners at University who in my expectation is that they covered some form of **life sciences in natural science at high school and have some basic science** principles of knowing things like ions and basic terms. **And the levels I teach when you start in first years by picking up where they left in grade t**welve. When you get to the second years there is an assumption that they have covered stuff –something they are not blank slates. There is an interest of doing the expectations because at the same time we expect them to have covered, they may have covered but they may have not understood and they may have covered and forgotten. I know with modularise courses students tend to just look at what they have received and then they throw it away after examinations. So when I get to **facilitate teaching and learning a course, there are two** things that I am interested in. I am **interested in the developing the content** for which I have assumptions about what they know and what they don't know. I also have interest in **learning how they learn a particular topic, Concept or concepts**. How can you learn about this? Humanistic approaches talk about how people learn- they bring in knowledge. **You should provide them with learning experiences that they value, so that they value themselves and value the knowledge**. And in doing that the learners must be able to work together. So it is very important for my **teaching and my facilitation of teaching and learning to provide opportunities for students to learn from each other**. Because humanistic approaches are constructivist approaches where learning is dependent on social interaction. **So if you have been noticing here and there, there is an interest to build the knowledge first of all more like cognitive approaches**. Where I come in and teach concepts like that, where possible I try to help my learners interact among them and say first what they understand and what they don't understand.

The Researcher: What will you count as the success of the task you give your students? Or what will count as evidence of learning for you for the class you are lecturing?

Dr Charles: That is a difficult question but let me try. I have always been asking myself and everyone else about **meaning of the word learning**. That is why I say is a difficult question.

Learning is a complex process and there is not one form of learning. So when you look at this student that you are working with, this is a teacher training institution. There are many prongs; the **first prong will be the learning of content.** When you have your learners (students) you want them to learn content and be confident with that content. **And then the next one you want them to learn how to learn** that content which is for me that is very important especially in South Africa where there has being problems around teaching and learning which in some cases it has being mechanical. **So preservice teachers have to develop skills learning how to learn themselves s**o that they should be able to develop skills how to learn and see it in their future learners. **And then the third one is learning to teach so there are three** main components that really concern me when I am preparing to teach. So I would like to see my students developing **content showing that they have enough content**. I will like them to show skills **around how to learn and this involves thinking** as well in **PCK terms** they call it **pedagogical reasoning- thinking before you go to class.** What is it I want to develop and how am I going to develop it and how my learners (Students) be able to show it, and then the **interest on teaching**. This one the interest on teaching, when I was a student from high school I started noticing from high school how teachers teach. **Different teachers come with different strategies** to teach and **some are interesting and some are boring**. Some use the book straight away some brings a piece chalk and they teach. All of that is a mix of how teachers teach and some bring in activities fun and once you are learning have jokes.

The Researcher: just like you do.

Dr Charles: well I don't know but what it comes to is that how do **teachers portray themselves when they are in front of a class**. How do they prepare themselves in order to **deliver content** in ways **that students will relate to it**? So there are three interests in terms of content, **learning to learn and learning to teach.** And then preservice teachers pick what they think will work for them and take it along.

The Researcher: what will you count as success for your lecture episodes for a complete session on a topic?

Dr Charles: Depending on the **knowledge** that am working with. IF I were to be teaching about the heart and the heart beat and other **content based** topics. The environmental ecology is a topic where one is teaching in one way as **an activist** and in another way **building content**. SO the teacher educator lies at a boundary you have to be able to move between makings people realise the kind of life they are living in. What people have normalize and seems to be normal and right should actually through the **lessons you teach them** show them this is not the best way things should be. And then they should be able to come to a point where they make decisions. **What is my role in this? And if I have to eat a sweet and there is aplastic bin will it matter if I take the sweet to drop the wrapping in the bin** or just drop it on the ground or keep it until I find a bin you know. That is the reasoning behind having such a course. Then if I am going to look at my success, it is the **discussions within the lesson**. What kind of **discussions** I am able to stimulate? **Whom are they going to blame**? If you notice the South Africa scenario they are saying the Government. If you listen to the

TV today, if you listen to the radio today it is the Government. The government is not doing, the ANC is not doing, the party is not doing but what are the **communities themselves** doing amongst themselves? If for example **a community has drugs** laws are these **drug laws not part of their system**? Have they not seen their children taking Drugs and keeping quiet about it? Have they not seen the police receiving bribes and not saying anything about it? And now that it has gone to a certain level, a level where **it is uncontrollable** they are now saying the governments when everyone is supposed to be responsible. So we are going back to the course every course is supposed to **build responsibility amongst** the people involve. For me once there are discussions that start to question **who is not responsible**? **Where do I come in? What is our role?** Are we not failing are we not just a drop in the ocean? Then I will count that as a success of my lectures. And also sorry can I add you will notice that the tutorials will **enable them to try and teach particular topics**. Then when preservice teachers are able to **identify aspects in the syllabus** because I did not prescribe them so that when they go into class they will be able to grow from there. For me that is success.

The Researcher: what was your reasoning behind the task you give to the life science year three preservice teachers?

Dr Charles: I was trying to show them that there are interest groups. So if you have a particular interest you look for people with the same interest and then you develop your ideas concretise your ideas. And when you have those ideas you are able to work with another **community.** And so at the same time it was a method for these students to develop points for the particular perspective which is the specific groups they will develop the points there which they will bring to the larger group- the stake **holder** group. So the multi stake holder group will be showing what happens in reality. In reality we have **small communities of practice** that generate ideas which they then take to **bigger communities practice through collaborative activities and collaboration is key there**.

Interview transcript with Ms. Rose 9/10/2018

Researcher: Researcher: Good morning I just want to get your perspective s about your lecture slides and how you facilitate interaction while you are teaching Cell biology (life science iii).

Ms. Rose: to get **students actively involved** I believe in teaching through **questioning** not just dishing out the content, but to **encourage that interaction** by **continuously asking them questions** around the topic at hand.

Researcher: For the design of your lecture slides do you have any ideas about teaching and learning embedded in them seeing you are training future teachers?

Ms. Rose: coming back to the slides it will be ideal to have those **cues** that **guide them to the content that** is being dealt with but I know that most of my slides don't have those questions

that require them to think about sections of the **content they are taught**. But I make a conscious attempt that during my teaching to ask as **many questions (OTL)** as possible related to a particular slide to monitor whether they **understand what is on the slide (content).**

Researcher: What ideas of teaching and learning do you have entrenched on your slides design in both methodology and content?

Ms. Rose: let me say during method lectures what I strive to do is to make them conscious of the fact that the **knowledge** they are getting is not only for them, but it is to equip them with those **skills to make the content (modeling practice)** that they are presenting accessible to those learners

Researcher: What will you count as successful lecture session for a topic example introduction to cells?

Ms. Rose: I would say that at the end of that whole topic yea what I picked up and which I found very rewarding and fulfilling on my part as a teacher educator is that I realise that their **knowledge bases seem to have being enriched**. And they could see the differences for instance cell and cell division that they did in high school as well as in first year they did touch on that but I could see them seeing the **differences and appreciating the detail** and clarification that they attain **about cells and cell division**. Though I could see that most of them came with the perception that we know cells we know cell division but at the end of that topic or let me call it module they could clearly see the **differences between for instant the two types of cell division.** And I didn't even have to ask them their contribution was evidence to their understanding **seeing this distinct difference between the two types of cell divisions** and their role.

Researcher: at the end of your overall lecturing session what will be the evidence of learning for your students

Ms. Rose: to reiterate my response to your previous question is that I could clearly see that there is an **extension to their knowledge at the ends of that module a**nd a deeper understanding of cells and cell division. For your question I wish I had given them a test before at the beginning and a test at the end just to see the difference I **their performance and understanding of the content**. Because when I looked at their test, they only wrote a single test. When I looked at their marks for the test some of the **responses were so detailed**

that I was even surprised at the extent to which **they performed and were able to provide a detail**. That shows **their utmost understanding of the content**. That would have been solid evidence if I had given them a test at the beginning and at the end.

Researcher: What was your thinking for task assignment especially the task that they have to engage in discussion of the CAPS document?

Ms. Rose: when it comes to preservice teachers and referring them to CAPS, is to make them aware of the **sequence of the topics** and for them to also be able to question the sequence that is put in **the CAPS document in relation to their understanding of the topic**. I will give you an example for instance **mitosis cell division is taught** in grade ten, whereas meiosis is taught in grade twelve. So meaning that there is a gap where they totally forget about **what mitosis is**. Whereas that structure is a **national document**, it separates content and it disturbs the understanding of content that should be seen as similar since they are both types of cell division. **But then their sequence placement disrupts the continuum** that is needed in their **learning and understanding and not separating these two types divisions all together**. Like for instance here on campus in their third year of study do cell division and mitosis and in fourth year they do meiosis. And link it to its role in reproduction. Which means they can see **the continuation and the fact that after meiosis has played its role in reproduction, mitosis comes into play by bringing about the growth that is needed of cells into tissues into organs and systems** and so on. Yea when you say higher education do you mean teacher education or higher education general?

Researcher: I mean teacher education because other students outside teacher education are studying for their own personal understanding however preservice teachers training is different as they are being prepared for their future learners and classrooms.

Ms. Rose: As a research and a teacher educator in higher education…

APPENDIX G: CATEGORIES EMERGING FROM ONE CODED TEACHING TRANSCRIPT

CATEGORY 1TE INTRODUCES CONCEPTS WITH QUESTIONS WITHOUT PROVIDING ANSWERS

3 what is ecology and what is population ecology? TE asks the class a question to review the students' prior understanding of ecology in general. **OTL**

4 Why do we study these two? TE asks the class a follow up question **OTL**

5 What is ecology and what is population ecology…? TE ask a question for preservice teachers to differentiate between ecology and population ecology **OTL**

6 What is population ecology and what is ecology? Why do we study the two? TE ask some follow up question to the class OTL

34 What do you understand by population density? TE ask the class a follow-up question **OTL**

35 Yes …So, what is density? **(**TE repeats a question for the class to elaborate on the concept of population density. **OTL**

CATEGORY 2TE PROBES preservice teachers for elaborate meaning for clarity

7 Any other contribution? (TE ask for additional rejoinder for clarity **OTL**

8 How do you differentiate it from community ecology? TE ask for additional response for clarity **OTL**

9 But why do we study population ecology or ecology? Or, why do ecologists study ecology or population ecology? TE ask a question to the class and a follow up question to elaborate the initial question **OTL**

10 …But why are you saying sustainable development? TE ask for an additional elaborate meaning **OTL**

14 So, the question there would be how the population decreasing or increasing is and based on what? TE asks preservice teachers what causes a population of the same species to decrease or increase. **OTL**

30 And then for random? TE probes further for clarity of response. **OTL**

34 What do you understand by population density? TE ask the class a follow-up question **OTL**

35 Yes …So, what is density? **(**TE repeats a question for the class to elaborate on the concept of population density. **OTL**

43 So, what are the kinds of things that you can draw from this population pyramid? (TE ask the class to give an interpretation of the population pyramid) **OTL**

44 What can you draw from the pyramid? (TE repeats the question for an elaborate response) **OTL**

45 So, what can you draw from the population pyramid? (TE repeats the question to the class for emphasis to check students understanding) **OTL**

46 Which cohort are you looking at? (TE ask the class a follow up question for clarity) **OTL**

47 I mean which age group? (TE rephrases a question to the class for clarity) **OTL**

CATEGORY 3 TE review student's response and gives further explanation

11 So, if we talk specifically about human population, we are looking at how resources are distributed. TE reviews a student response and further explains the concept. **OTL**

12 So, by knowing that Wits School of Education we have 3000 students…that is the population in this campus…so they know how they can distribute the computers and everything. TE further clarifies that knowledge of population concept will help in resource distribution. **OTL**

36 So, it is per unit area at a given time and that is very important because when ecologists study a certain population, they look at that specific area. TE reviews a student response and elaborates that population density is the number of individuals per unit area at a given time **OTL**

50 And we also have the age structure which is the representation that shows the number of individuals in different age groups…and that is a cohort which of interest to population ecologists to understand the dynamics. The cohort has a feature called fecundity which is explained as the number of offspring produced per standard time and in most cases, they measure that per year. TE reviews a student response and expounds further for clarity and

further defined a cohort feature of a particular population as fecundity which is the offspring produced per standard time. **OTL**

62 Yes… it is the same as average. TE review preservice teacher's response and explains further **OTL**

CATEGORY 4 TE USES PPTS SLIDES TO ILLUSTRATE A CONCEPT.

13 I told you that I will show you the levels of ecology. So, it ranges from organismal ecology to global ecology. With the organism, we are looking how the organism responds to temperature exchange. So, it is about the behaviour and physiological features of that organism. TE further explains the levels of ecology using a PPts slide **OTL**

15 Those we call the levels of ecology but the focus is now on population ecology. So, we have said that ecology is the study of organisms relate to one another and their environment and populations are organisms of the same species that live together at the same time TE uses PPT slides to illustrate a concept. **OTL**

18 the boundaries of the population are able to expand or shrink and that is **OTL** the focus of the next slide. Can I continue?

19 That was its range. It made its way into the north of America and expanded its range. That is why here it says immigration from Africa (shown on the slide). It means it has expanded its.

How individuals are spaced within 'range'? (Reading from the slide).

23 How individuals are spaced within 'range'? (Reading from the slide). TE uses a PPt slide to engage the class visual prompt **OTL**

37 That is why I said at the beginning of the lecture that the range is very specific…very important in population ecology. So, it is the number of individuals per unit area and demographers study the statistics of populations (read from the slide) TE uses slides in explaining the specificity of range in population ecology and defines it as the number of individuals per a unit area. **OTL**

54 So, the other thing that population ecologists use to study populations is what we call life table. And the life tables show you the survivorship of organisms as time goes.

So, what they do is that they take a cohort and follow their fate to a certain extent. So this one (life table displayed on screen) TE uses PPts slides to explain the concept of survival of organisms in a population over time **OTL**

55 What you need to know is that life tables show you the survivorship or organisms. And it gives rise to what we call the survivorship curves. This is a complex one and. It shows you that they have separated females and males. In most Biology textbooks, they separate the two…they focus more on females because they are the ones which are capable of increasing or decreasing the population size based on the fertility rate. So, as I said, they follow a particular cohort and note the number of individuals that survive and that die each year and at the end, they produce the survivorship curves. We have Type I, Type II and Type III. For type I, mortality occurs at an elderly age. That is for human beings as an example TE explains the general survival ship curves in organisms and uses the PPts slide for clarity for the class. he further elaborates that in most text the focus is on females as they are the determinant of an increase or decrease in a population. **OTL**

CATEGORY 5 TE EXPLAINS VERBALLY ONLY

12 So, by knowing that Wits School of Education we have 3000 students…that is the population in this campus…so they know how they can distribute the computers and everything. TE further clarifies that knowledge of population concept will help in resource distribution. **OTL**

16 So, people in Limpopo in Vhenda and people in KZN fall under the same species but they are of different populations. When ecologists study different populations, they look at the boundaries TE explains the concept of boundaries with examples. **OTL**

20 So, if population ecologists where to study the distribution of cattle egret, and they know that it is only limited to Africa, and not anywhere else back then, they would make informed decisions on their studies. So, if the boundaries/range of a particular population shrinks, it means there is a possibility that the population will become extinct. TE uses verbal explanation only to describe concept of population shrinking **OTL**

21 So, when we talk about dispersion…dispersion is different from dispersal. During pollination, the seeds or pollen grains undergo the process of dispersal but dispersion is about

how individuals in particular population are distributed. TE uses verbal explanation to differentiate between dispersal and dispersion **OTL**

22 So, clumped dispersion, we get individuals here (drawing on the board – dots to represent organisms on 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. TE uses verbal explanation to elaborate further the concept of dispersion as clumped, random and uniform **OTL**

31 But one thing that you need to know is that they are not static. These dispersions are not static. So, they very same population which shows clumped dispersion would show a random or uniform dispersion at some point. It is based on behavioural activities. For example, the butterflies would be clumped for a certain activity and then they would disperse if they are going to mate or something like that. TE reiterates that dispersion in population depends is not static but is based on behavioural activity. **OTL**

32 Yes, that and the social behaviour…so for random, it is not common in nature because with random, it would mean we have abundant resources in that particular environment. That is why it is not common in nature. And then for uniform, it results from competition. With animals, some animals would mark their territory…so that would results in uniform spacing. TE elaborates further about dispersion in population that it dependent on social behaviour and gives examples in plants and animals. **OTL**

33 The social interactions for clumped dispersion also provides advantages and some of the advantages include animals being able to protect themselves against predators. I mean how can you fight a guy who is mugging you alone? TE elaborates on the advantage of clumped dispersion as a means of protection from predators. **OTL**

38 Population parameters we are talking about the mortality, the natality; or the birth rate and death rate…we are talking about the emigration and immigration. So those are kinds of things that indicate whether the population is decreasing or increasing. TE explains the concept of population parameters and their relevance in the population increase or decrease OTL**.**

39 I mean if we have more people who are above 50 years, and less people who are in between 15 and 30, what would happen? We wouldn't have an increasing population because those people are no longer giving birth. But with people between the age or 15 and 30, they have high fertility rate. TE explains the concept of increase in human population based on their age and sexual productivity **OTL**

40 And we also have life tables and survivorship curves which explain how populations are increasing or decreasing. And we are going to talk about each of those. Yes, TE emphasises how life tables determines how a population decreases or increases. **OTL**

41 I am just focusing solely on the age structure but of course there are more factors that affect the increase or decrease of a particular population. Now I am just talking about the age structure. So the assumption is, neglecting all other factors and only considering the age structure, people around the age of 50 have low fertility rate… TE further expounds age structure and population increase or decrease without the interference of population parameters amongst human beings. **OTL**

42 Yes, in human beings…but around the age of 15 to around 25 or 30 have high fertility rate. If we assume that. So, I am not saying that there are factors which affect the population increase. There are but now we are just focusing on the age structure. Any other question? TE further illustrates the age of productivity in humans as from 15,25 and 30. and the assumption is that fertility is high around these age range **OTL**

48 Okay, you would need to explain more…when age increases the population size decreases (TE elaborates a preservice teacher's responses for clarity) **OTL**

49 Okay, you would need to put in another way… Not that the population size decreases but the number of people in that age group become less…so, it is not age which affects the increase and decrease of populations. It is the age structure and the structure we are talking about the groups here. I am not sure TE elaborates further that the age structure of individuals in a population determine the size of the population. **OTL**

53 So the sex ratio in those kinds of populations is very important. So, there needs to be a balance so that the population can increase. One of the things that…TE explains the importance of balance between the sex ratio of a population as an index of the population increase. **OTL**

57 So you sample several times and you take a mean number of that and to get your estimate population size you will have N is equal to…if we take A; of course you need to define your variables…If we take the capital letter A as the area of the land or the habitat, and small letter a as the area of the quadrat, the formula to calculate the estimate of a particular population size should be…and then n would be the mean number of organisms that you get as you sample. TE explains verbally only how to estimate the size of a population by sampling several times in an area. **OTL**

58 Okay what I am saying is, for this method, there is a mathematical formula. It does not matter which variable I am using. As long as you are able to define the variables that you are using. So "N" would represent the estimated population size and that is what we are looking for. TE explains verbally only that there is a formula to determine a population estimate but the variable has to define. **OTL**

59 To estimate the population size, and remember it is not the actual population size; it is the estimate. You will never know the actual population because it will take you some time. Even with the human, they just estimate. TE gives verbal explanation of population estimation. **OTL**

60 So, you would need to know the area of that particular land…divide by the area of that quadrat and multiply that by the number of organisms. But how do you get the number of organisms when you have sampled seven times? You need to get the mean number of those organisms. TE further expounds how to do actual population estimation **OTL**

63 And the last one is the mark-recapture method and it is very popular…so, they will take the whales and tag them or mark them and note the number of marked whales. Then they would return them into their habitat. The assumption there is that the tags won't affect their behaviour and some of the things that they consider is that there is no migration. So, they don't consider the migration. For the second capturing, obviously they will capture the marked organisms. And in order to estimate the population size there (refers to the slide for the formula). TE explains how population size is estimate further for clarity **OTL**

CATEGORY 6 TE USES ILLUSTRATIONS ON BOARD

52 So, the idea behind this (the question of the activity) is that…I think I have already explained this. So, if you have a pyramid like this (draws on the white board) you can see that

here, between the age of 15 to 25, we have more people. So, it means that there are high chances that the population will increase. But if you have something like this and it looks like this at the bottom (draws another example of a population pyramid); chances are, that particular population will collapse because these people at the top there are no longer reproducing but the people here have high fertility rate but there is less of them than here. TE uses illustrations of population pyramid on the board. **OT**L

56 Of particular interest here, I want to focus on the quadrats and the mark-recapture method. With the quadrats, they use something like that (pointing at the picture on the slide). The size of the quadrats depends on the area of the land that you want to investigate. So, you would need to know the area of the land or the habitat. And you need to know the area of the quadrat (writing on the board). The other thing is that you would need to know the number of organisms that you get in each quadrat as you sample. TE explains sampling of organisms using quadrats and the mark-recapture **OTL**

CATEGORY 7 TE EMPLOYS PRESERVICE TEACHERS WITH MIND ENGAGING ACTIVITIES

24 But, what I want you to think about now is why do you think individuals would be clumped in a specific range**?** TE ask question to deeply engage the mind of his preservice teachers. **OTL**

25 Why do you think individuals would exhibit a random spacing or a random dispersion? Why do you think that individuals would exhibit a uniform spacing? (TE assigns an activity to the class. **OTL**

26 So, in your activity, you need to think about why…TE gives further instruction on preservice teachers' task. **OTL**

27 So think about why individuals in a population would be clumped, random, and uniformly spaced. TE gives further instruction for preservice teacher to engage their mind to answer why different types of dispersion in a population. **OTL**

28 So, I am giving you 5 minutes at most…absolute silence, I want you think of the question and write down your thoughts. TE instructs preservice to think and write their thoughts' **OTL**

29 Can I have one person who is brave enough to share the reasoning behind the three kinds of dispersion? TE instructs preservice to share his/her reasoning about the three types of dispersion. **OTL**

51 Okay, can you do that activity (discussing the influence of sex ratio and age structure on population growth rate) TE instructs the class to discuss the influence of sex ratio and age structure to the growth of a population **OTL**

Appendix H SAMPLE OF FOCUS GROUP INTERVIEW

Good morning every one why I want to have this focus group interview is because this lab has been my data site. I know I have worked with you on your tutorials practicals and on your task but then I want your perspective. I know what I have observed having your perspective might give me an insight into what you are thinking and how you engage on your task as teachers to be. Preservice teachers you are being prepared here to go into your future classroom so these are the questions I intend to engage you with. I have three questions I want each one of you to give his own or her own perspective is that okay with you?

S: Yes, is that how we benefit from the tutorial

S: Just listen to the question then you can answer….

R: What was your experience on a task in group?

Karabo: Okay as for me as the one who is seating at the beginning am karabo… group discussion has really help a lot because in group discussion you get to know what the other people think; you get to **learn** from your peers. So I think it is better, it is a good **strategy of teaching** because learners get to learn from their peers because some of us can't even understand the **English of our lecturers**. So when your peer explains to you in simpler English because at school we did English as a first **additional language** not as a home first language. So **our peers in group discussion** try and use simpler English and you know some of them have a **better understanding of the content** that is being taught so when they explain to you, you get a better understanding. And discussing with your peers also helps because sometimes we are scared to ask our demmies because they are rude. So when you ask your peers they help you.

Motomo: my experience is more like hers. Working with my peer boost my confidence because they are my peers they could understand me. And I have gained a lot from them because they **enhanced my ideas on some concepts** and content yeah that is basically like hers.

Lebo: also with me group work has being helpful as we **learn especially life sciences**. Because we have different areas where some are strong and some are **weak and group discussion** is where you help each other. Through our weak point and strong points.

Sapiso (m) my contribution is similar to hers, we get to learn from our peers they get to **enhance our ideas and what we know**. And we relate more to our peers than and it has help me a lot in that part.

Lerato: okay I think working in group has being beneficial as you know we are people we bring **different prior knowledge** that we bring into and different experiences. So sometimes there might be a point that I might have missed in class and my **peer may enlighten me** on the point that I have missed. So I think is beneficial to work in groups because we help each other in areas where we are not sure or in areas where **we concepts might have missed a few** here and there.

Researcher: okay as you are discussing in groups what will count for you as success in the group task?

Karabo: to me what will count as success is when everybody in the group has participated and when each group member has an **idea of what we are discussing** after a group session and have made an input? So group work should be about **participation and about encouraging each other**. So everyone should be given an opportunity to express themselves that for me is successful group work.

Kfriend: and a gain for a given task at the end of the day we reach a conclusion about a given task that for me counts as achievement or when we agree upon our task so that is success for me.

Lebo: same with me in a group work what will count for me as success is when we are **building each other**. When someone gives an answer that might not be correct we don't get to attack them but correct them at the end of the day is not about who can do all the work but as a process of learning.

Sapiso: for me what will count as success is when everyone in the group gets to **understand a certain topic or concept**. For me that counts as a success.

Lerato: and for me what will count as a success each and every one of us is **playing their role** in a group and we achieve the learning objective for me that will be successful. If we all do our role if we all **participate and if we all get something** out of the group work.

R: Thank you. So how will the key components of this task help or hinder your learning?

Kfriend: in life science I fell coherence is important. So if you are teaching you need to start from the big ideas so the resources we are using is helpful in that manner. Like the CAPS **document use in our task** it shows us the steps to follow to teach topic example photosynthesis. So coherence in presentation is very important.

R: OKAY.

Karobo: with me what I have **learn is that coherency** is important but is a matter of whether you are teaching or learning inductively or deductively. So that manner will tell you whether you are learning from the big idea to the smaller idea or from the smaller idea to the bigger idea, depending on what you are doing and how good you are when answering a question using that method. So what we been using in the lab the resource and notes are coherent and helpful in most cases they teach you **the bigger idea** and then go deeper with **the smaller** ideas so that you get a deeper understanding of what is being taught.so what I can say here for my journey as a life science teacher is that they have taught me to go an extra mile. You know when we are unpacking the CAPS document I have also learnt in the CAPS document there are some things which I will refer to them as misconception and not mistakes. Here they have taught us to go an extra mile beyond the CAPS document. Because in most cases the CAPS document was written by people who are not life sciences experts and some of them are not teachers so they don't know what to expect in the classroom.

Lebo: so with me so far as a life sciences teacher I have seen the importance of **coherence of life sciences learning especially during teaching when my learners** had to do plant cell and animal cells. I started by the cell division, unity and then we got to the tissues. At some point I even as the learners do they see the logic of the concepts that we are doing. I feel like the way we learn life sciences it even helps us to be logic in general. Okay so I feel like in any subject but particularly in life sciences. It is important to look at the topic and make sure that you know the concept about the big ideas and how you are going to go about teaching it so that you get meaningful for your learners. So when we are given a task, first we need to look carefully at the question what it wants us exactly to do so that we know the concept surrounding the big ideas. So as well also we need to be able to have different teaching aid and modes of representation so that we can be able to represent the concepts in a good manner. In a manner that someone who has not done life sciences can understand what you are talking about for example the use of different teaching aids and different representation to make the content meaningful and so that you can understand it. Things like the CAPS document, the content the resources you can use and you as the teacher you need to think deeper as to say which example I can make my teaching meaningful. Because we are encouraged to use text books, video mind maps etc.

Thank you for your time.