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With the title:

First-year Life Sciences students' preparedness for the laboratory learning environment

FACULTY OF EDUCATION

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I. ABSTRACT

Higher Education Institutions in South Africa has teacher education and training been enrolling students as preservice teachers in first year Natural Science Education disciplines of which one Life Sciences Education is one of them in their undergraduate studies. These first-year students are coming from different schooling backgrounds. Some schools are no-fee paying schools which have been categorized as quintile 1 to 3 systems which are categorized by low-income families, while others are coming from the well-resourced quintile 4 to 5 system which service the middle socio-economic and higher socio-economic. The lower quintile schools rely on the subsidy given to them to teach and hence they have been viewed as disadvantaged schools because of poor infrastructure and inadequate material for adequate teaching and learning. These facts continue to prevail even though, South Africa, as a nation, has moved past 25 years of democracy.

These divisions in schooling backgrounds have had a contribution in disparities in students entering the universities to enrol for a Bachelor Education with the aim of becoming sciences educators once they qualify as teachers. Students coming from disadvantaged backgrounds continue to lag behind those students who are coming from well-resourced schools. Such disparities in first year classes at the university where this study was conducted has been a source of low throughput rates and higher attrition rates in the universities which is viewed as a cause of concern. In first year Life Sciences such differences in schooling experience based on the social and economic status of these students has been seen as a source of struggle in not only the content knowledge of the Life Sciences discipline but has been seen as posing a challenge of exposure of first year Life Sciences students to laboratory environment and practical skills which is gained in conducting experiments, being involved in a learning processes through inquiry plus investigative

scientific skills expected from the envisaged natural Sciences and Life Sciences produced by the current teacher education and training curriculum. Schools also expect teachers to perform as 21st century science educators endowed with adequate skills that will assist them to be competent teachers. Exposure to practical work and working in the laboratories before enrolling for a Life Education at schools contributes to preparedness of Life Science education students for investigative skills and enable them to participate at ease in inquiry-based activities in the first year in the Life Sciences Education class at university level. This study is aimed at investigating first year Life Sciences education students for adequate and beneficial learning of Life Sciences education through laboratory environment. In light of this, the researcher set out to answer the question: firstly, seeking out factors that influence first year Life Sciences students' preparedness for the laboratory environment at a university that trains and educate Life Sciences preservice teacher. Linking to this question, the research explored how these first year Life Sciences education students demonstrate their levels of preparedness when doing their practical activities in a laboratory environment as well as the researcher also exploring ways of reducing gaps between students in a first year practical class which can be narrowed down to the extent of levelling the field for all students irrespective of where they did their secondary education.

Theory of Bourdieu of social and scientific capital provided the researcher lenses to interpret and analyse data collected through qualitative research methods within the interpretivist research paradigm. A purposive sample of four groups of five participants (n=20) was selected from a population of 91 Life Sciences first year students for focused group in-depth interviews. To address trustworthiness of the data and findings obtained from the study, triangulation was done using instruments; non-participant observations when students were conducting practical activities in the laboratory. Two practical worksheets were randomly selected on the first and last microscopic practical activities and data obtained from these was used to analyse drawing and conceptualization skills of the participants. Data obtained from the interviews were interpreted through using open codes, so themes were generated and discussed in view of literature review and theoretical framework. This study unveiled that there were indeed gaps between students coming from the two schooling backgrounds (upper and lower quintile schools). Another major finding on the study was that students displayed variable skills and conceptual understanding which agreed with the Bourdieu theory of social capital which was seen in this study as contributing to scientific capital.

It was further concluded that absence of exposure to resources needed to conduct practical investigations had an impact on lesser confidence levels of students who were mostly doubting themselves when conducting practical activities. When a guided inquiry was used as a strategy to engage students in doing practical work, results obtained from practical activities did not differ much with the results obtained by students coming from well-resourced schools.

Students obtained similar results when they were given a complex practical activity (plant tissue microscopic activity) at the end of the year. This study recommends that to understand that there are different backgrounds in knowledge of students when they come to university from secondary schools that a baseline assessment needs to be administered to students to get an understanding of competence in the fundamental practical skills like, drawing skills, labelling skills also engaging students on activities that will challenge them to engage in inquiry-based learning. Early detection of knowledge and skills gaps in the students first year Life Sciences practical work could benefit students with skills that they need through various scaffolding methods.

Laboratory learning requires pedagogies that will ultimately allow students who were struggling initially into better achievers. It is further recommended that schools need to be consistently checked whether practical work prescribed in the school curriculum is being completed and that curriculum advisors should be aware of conditions of lack of resources and the capacity of teachers to conduct the practical work prescribed. Once students are exposed to inquiry-based teaching and learning, skills like critical thinking are more likely to come more naturally to them.

II. Declaration

I, Vusi Wellington Mazwayi declare that the work presented in this dissertation with a title: “First year Life Sciences Education students’ preparedness for the laboratory learning environment” is my work and where other sources were used for reference, they were acknowledged according to the Harvard system of referencing.

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Chapter 1: Overview of the Study

1.1 Background of the Study

Developing countries such as Sub-Saharan states, have been associated with wide disparities between social classes: such social stratification is in many cases caused by governments which adopt Western political ideologies in an unquestioning, unreflective way (Bokana and Tewari, 2014; Booyse, Le Roux, Seroto & Wolhuter, 2011). The wholesale adoption of such ideologies often polarizes a society into classes defined by socio-economic status (Fisher and Scott, 2011; Bokana and Tewari, 2014). Such economic polarization and social stratification may clearly be observed in ways where secondary and tertiary institutions of education design, implement, and evaluate their curricula. South Africa has not been immune to the unquestioning adoption of alien, corrosive ideologies and has suffered the consequences: citizens are routinely classified according to their economic/social standing. These social classes have affected by, and/or contributed to the different schooling backgrounds associated with classification of schools within certain societal groupings. The South African education system itself, before the democratic era, was strictly arranged, pyramidically, according to race and social standing of inhabitants; with whites at the top of the pyramid and the only South Africans who could claim to be enfranchised citizens with full voting rights (CHE, 2013; Fisher & Scott, 2011; Booyse, Le Roux, Seroto & Wolhuter, 2011). The democratic dispensation post-1994 introduced, on paper, equal education for all citizens of the country, aiming at redressing the imbalances that were created by the previous regimes (DoE, 1998). Given that white settlement, colonial control and fully articulated apartheid lasted for three centuries, there was little realistic possibility of liberating the minds of a non-white majority that had been deliberately kept in servitude for so long.

The challenge of educating a largely uneducated majority within twenty years of democratic government has been met in some respects. But white critics from the previous regime are quick to point out the shortcomings of attempts by blacks to correct the offences of the past; such critics routinely point out the failures of OBE with relish. This field of critical conflict is rehearsed through media, academic journals, and social media: sniping and point-scoring are used extensively (Bokana & Tewari, 2014). This research is conducted against the background of this conflict and with full awareness of the politics of educational hegemonies, past and present.

Legislation for democratisation of education in South Africa resulted in the sudden order to transform previously segregated education systems into a single united education system for all citizens. The time frames and logistical demands for this order to transform, though ideologically laudable, were unrealistic in practical terms. The paradigm shifts were recently referred to as "the education for the 21st century" by researchers in education curriculum (Meyer and Land, 2003). While the system of education changed by act of parliament, the practice of teaching at schools and tertiary institutions, has not necessarily been transformed entirely within the comparatively brief period of two decades; especially when measured against the entrenched patterns of three centuries of enforced serfdom for non-whites. The issue of correcting anomalies created by the previous dispensation involved redress of disparities in schools created by the previous regime: this process has proved far greater than initially imagined. In practical terms the status and condition of schools and tertiary institutions have stagnated in many instances.

Wealthy parents of learners and working-class parents who saved sufficient money enrol their children at ex-model C schools which are already well resourced. Some of the benefits these schools offer are for example, functional libraries and laboratories as well as qualified teachers to teach disciplinary knowledge to enhance learners' performance in scientific disciplines (Meyer and Land, 2003; Booyse, Le Roux, Seroto &Wolhuter, 2011). Rondebosch Boys' High School, a Model C school in Cape Town, for example, has eight rugby fields while Langa High in the same city some schools do not even a have a single one. The outcome of the segmentation of schools by fees has perpetuated an increased socio-economic polarity.

Diverse students enrol for Life Sciences education in teacher training and development at universities. Some of these students studied at affluent schools having a range of resources while the majority coming from under-resourced schools characterized by under-qualified teachers. Such teachers struggle to impart disciplinary knowledge in Life Sciences classrooms due to challenges in ontological and epistemological discipline knowledge as well as absence or under-resourced laboratories in many cases (Botha and Reddy, 2011; Meyer and Land, 2003; Booyse, Le Roux, Seroto &Wolhuter, 2011).

The University of Technology where this study was conducted, like many other universities in the country, is facing a challenge of enrolling students coming from very different schooling backgrounds. Hence, this study focused on students experiences in conducting practical work in a laboratory environment. In a manner of the nature of Life Sciences, most modules require laboratory work. Therefore, Science Education at tertiary level requires acquaintance with, and depth in, content knowledge as well as practical knowledge; since the discipline itself requires foundational knowledge that should be acquired at a secondary education level. This secondary level practical work is seldom completed or even adequately done with the consequence of burdening teacher educators with work that should have been done at secondary school level.

The central question and challenge this study addresses is how to design a university program that can cater for students from different backgrounds as well as which interventions that bring equality can be effected since some of these students are required to have prior skills and competence to conduct practical work.

In their preparedness for tertiary level education, first-year student teachers in Life Sciences have manifested worrying signs of dealing with socio-economic disparities or stratification in their classrooms that also involve skills to conduct laboratory activities. Such manifestations of diversity contribute to anxiety among those students who are just introduced to working in laboratories and carrying out scientific experiments as required by Life Sciences discipline at a university level. Students who are coming from more privileged backgrounds are mostly endowed with skills and laboratory knowhow which displays their initial exposure to laboratory work as they attended schools where such exercises were performed in school laboratories by skilled teachers. This is not the case for most learners in South Africa (Botha & Reddy, 2011).

The difference in schooling environments has been typified by the exclusion or inclusion factors in practical work performed in Life Sciences' laboratories which is required in the Life Sciences school curriculum. Therefore, results of the inherited differences in schooling system contribute to uneven performance of students in Life Sciences' practical work (Botha & Reddy, 2011; Willcocks and Mingers, 2004). The preservice teacher education curriculum requires Life Sciences teachers produced by universities to be acquainted and competent in using laboratories as places where learners will be taught adequately (DHET, 2018).

Higher Education Institutions in South Africa enrols students from all over the world as well as from different schooling backgrounds despite their disparities emanating from schooling backgrounds as long as they meet university entrance requirements. The entry requirements of Life sciences as a discipline in the institution where this research is conducted requires students to have obtained at least 50% in senior certificate for them to specialise in Life Sciences in the Bachelor of Education SP-FET program this is despite the minimum requirements for enrolment in Life Sciences as a sub-discipline of a broad field Natural Sciences discipline. Furthermore, students who enrol to study Natural Science are supposed to have to have met the same requirements in Physical Sciences as both subjects are sub-disciplines of broad field of Natural Sciences (DHET, 2018). However, there is an appreciable number of students who display unpreparedness when they are required to perform practical work in a laboratory.

This state of affairs could be due to the fact that many students have been deprived of these foundational skills at the secondary school level resulting in them to be struggling to identify or even identify apparatus that are generally used in the discipline. Had such students been adequately prepared in laboratory practical activities before enrolling for the first-year Life Sciences course, the task of teacher educators and staff working in the laboratory environment would be to focus on deeper learning; based on students building on already existing practical knowledge obtained from secondary schools.

1.2. Research Aim and Questions

This study investigated the preparedness of first-year Life Science student teachers for adequate and beneficial learning in the Life Sciences laboratory environment. The nature of the Life Sciences discipline requires practical knowledge which can be acquired by actively involving students to do practical work in Life Sciences. It is in this light that the main research question for the study is posed as:

What factors influence first-year Life Science students' preparedness for laboratory environment at University level?

The following sub-questions focus the study:

1. How do first-year Life Sciences students demonstrate preparedness when conducting practical work in the laboratory environment?

2. How can these students' preparedness or lack thereof be ameliorated?

1.3 Research Aim

The main aim was**:**

Investigating factors contributing to preparedness of first year Life Sciences students for the laboratory environment at University level.

The sub-aims were:

1. Investigating whether first-year Life Sciences students demonstrate preparedness when conducting practical work in the laboratory environment.

2. Suggesting ways of scaffolding under-prepared first-year students to narrow gaps resulting from lack of exposure to practical work in the Life Sciences laboratory.

1.4. Theoretical Framework

This study is located within Bourdieu's theory of social and scientific capital (Bourdieu, 2005). The diverse backgrounds of students include the social field and the social space that they occupy, contributing to the environment and affecting the relation between knowledge and skills of students. This interdependence influences the coping strategies that Life Sciences students apply in order to increase their scientific, cultural capital and disciplinary knowledge. Scientific capital is described as the disciplinary knowledge that endows Life Sciences students with peculiar skills which are controlled by the environment. Life Sciences students, based on their diverse backgrounds, are differential agents of scientific and cultural capital in the disciplinary field. As agents, they learn to interrogate their own acts of knowledge acquisition and learn to recognise their abilities among peers (Bourdieu, 2005). The implication of this interrogation is that learning occurs in a graded manner. Students act within the constraints of the rules of a particular disciplinary field; in this case Life Sciences and gradually learn to question the world around them in an informed and structured way.

1.5. Literature Review

1.5.1 Importance of the laboratory in the Life Sciences discipline

Laboratory activities have long played a distinct and central role in the science curriculum in communities, high schools and universities which can afford expensive facilities of science laboratories. Science experts have suggested that many benefits accrue from engaging students in science laboratory activities (Hofstein and Lunetta, 1982; Lunetta, 1998). Developing students' scientific skills, knowing how to plan and perform investigations and to critically analyse results have been the key purpose of exposing Life Sciences novice teachers to laboratory practical work. In support of the above claim, Momlok-Naaman and Barnea, (2012) assert that two of the most important goals when engaging in laboratory work are (i) to link theory and practice and (ii) equip students with laboratory skills. For students to possess all or most of these skills, students need exposure to basic laboratory environment. In the case of first-year Life Sciences students, their experience in performing practical work is required: anxiety or doubts need to be dispelled for them to be appropriately skilled and confident as future Life Sciences educators.

Hodson (1990) criticizes some practices in executing laboratory work by stating that they are unproductive and confusing due to lack of proper planning. The above statement implies that laboratory work could be both time-consuming and expensive compared with other strategies of instruction, such as using models for demonstration purposes. Whenever a practical experiment is executed, there is much planning that needs to be done to ensure that all elements and equipment have been tested. This is done to ensure that time for the investigation to be undertaken is not wasted by last-minute arrangements. Everything has to be done in order to enable the students to focus upon the task set. This attention to planning reduces pressure on the person who is to instruct and facilitate the investigative exercise so the lecturer can be sure that the task will be completed within the specified time.

Preparation minimizes anxieties for students: the aim of this teaching approach is to ensure that students engage in the enquiry and gain investigative skills that develop a culture of scientific enquiry. Much time spent in solving problems can be saved through preparation of the exercise beforehand.

The literature germane to this area of study shows that at some schools that have laboratory resources, there is evidence of inadequate or improper use of the necessary, basic resources (Syh-Jong, 2007, Bone & Reid, 2011). This situation can compromise the purpose of the Life Sciences discipline since laboratory practical work is deemed necessary to impart inquiry skills as well as problem-based learning (Momlok-Naaman and Barnea, 2012; Hofstein 2004; Tobin, 1990).

According to Tobin (1990), laboratory activities appeal as a way of learning with understanding: allowing students to construct their own knowledge through science practical work; a lived experience which enables students to practise, think and act like scientists. Tobin states that meaningful learning is possible in the laboratory if students are granted opportunities to manipulate equipment and materials themselves with the opportunity to construct their own knowledge of phenomena and related scientific concepts. Gunstone and Champagne (1990) claim that learning in the laboratory often occurs when students are given ample time and opportunities for interaction and reflection to initiate and encourage discussions within the learning environment.

1.5.2 Teaching method in the laboratory

Not all activities in the laboratory are equally appealing to all students. An instructor must develop activities in such a way as to grant students the opportunity to investigate concepts, choose those that appeal to them individually and develop knowledge on their own. There are some methods that could be used to realize the above assertion, such as the inquiry approach (Momlok-Naaman and Barnea, 2012).

1.6. The Inquiry Approach

Inquiry refers to the work scientists do when they study the natural world; proposing explanations that include evidence gathered from the world around them (Martin-Hasen, 2002). This study does not advocate science itself but the benefits (i) of studying science in the laboratory environment and (ii) of teaching and learning science within a specific pedagogy. These benefits grant students the opportunity to transcend learning science through book knowledge alone. Students engaging in the knowledge production process through problem solving activities that involve proven methods used in scientific learning environments, find ways to identify and solve scientific problems. The benefit of individual experience in the laboratory is the increase in conceptual development through follow-up activities that are tied to the practical activity they are involved in. Teaching by using the inquiry approach differs from the teacher-cantered approaches to teaching and learning which deprive students of skills and capacity to operate at a high level of expertise (Hamidu, Ibrahim & Mohammed, 2014).

Inquiry-cantered laboratories have the potential to enhance students' meaningful learning, conceptual understanding and understanding of the nature of science (Hamidu *et al*., 2014).

According to Martin-Hansen (2002), there are different kinds of inquiry. Following her argument, the following have been identified:

1.6.1 Open or full inquiry

In terms of this concept as stated in her article, it is defined as a student-centred approach starting with allowing students to engage in a classroom environment where groups of students are given an opportunity to argue, similar to the Dialogical Argumentation Model which allows students to acquire knowledge based on practical investigation. Hands-on laboratory learning is congruent with constructivist educational principles: learners acquire, assimilate and own new knowledge which could have been stifled should the educator not have given them space to arrive at their own findings. By contrast, textbook-based science learning is rote learning and was a strategy encouraged through the teacher-centred approach popular under the obedience structures of apartheid.

1.6.2 Guided inquiry

In this case, like open inquiry, this form of inquiry takes place in a classroom context. In this approach, a teacher challenges student through choosing questions for investigation. A teacher guides student through a series of questions that provide scaffolding opportunities to students as they continue with the investigative exercise in the form of practical work. The difference in this case compared to open/full inquiry, is that a teacher assumes a role of being a mentor; providing mediation between students and knowledge required through the investigative practical. The teacher acts as a facilitator and a co-learner with the students: there is a possibility that students could discover novel methods of explaining and solving phenomena under investigation.

1.6.3 Coupled inquiry

This form of enquiry is described by Martin-Hansen (2002) as a combination of the above-mentioned forms of inquiry. Martin-Hansen, (*ibid.: 35*): states that having embarked on the guided inquiry, a teacher often reverts to a more learner-centred approach by implementing an open-inquiry investigation. In this instance, specific concepts can be explored through a teacher's 'skills of imparting knowledge'; giving students access to connect their concrete experiences to abstract concepts related to a learning cycle.

1.7. Research Paradigm and Methodology

1.7.1. Research Paradigm

The design of this study is underpinned by the guidelines of an interpretive paradigm. Henning, Van Rensburg & Smit (2004) state that a study that seeks to solicit participants' subjective views and perceptions about their environment requires an interpretivist paradigm. Schumacher and McMillan (2006) substantiate with a view stating that the interpretivist paradigm in social research is concerned with the world, which implies the person or group being studied frames the study. The implication raised within this paradigm is that the empirical study undertaken is the interaction between the researcher and the participants regarding their social context (Henning et. al.:20).

1.7.2 Research Methodology

1.7.2.1 Site selection

Qualitative methods of data collection were employed through focused groups of four first-year pre-service teachers' focussed groups interviews of six students in each focused group. Half consisted of students from disadvantaged backgrounds (students who came from schools without laboratories and resources) and another half consisting of students who came from schools with laboratories whether they undertook practical work or not before joining the university was constituted.

1.7.2.2 Participant selection

Qualitative data were gathered, in the form of in-depth interviews, conducted among four focused groups consisting of six first-year students each. Out of the population of 117 students, the researcher requested time to explain what his study represented and requested the students to volunteer to participate in the study. From the students who volunteered to participate the researcher asked them to indicate on a sheet of paper the following information: their matriculation results, whether they did both Life Sciences and Physical Sciences from school, whether they had laboratories for Life Sciences or not from schools where they matriculated, whether they did practical work or not at school and finally where their schools were situated (in rural areas or urban areas or city schools or ex-model C schools). Lastly, the researcher requested them to state how knowledgeable were their ex-teachers on the subject and methods that were predominantly used to teach school Life Sciences.

The questionnaires that were disseminated to first-year students were meant to inform the researcher of the suitability of students to form part of the study i.e. how sample was to be drawn.

1.7.2.3 Data collection

In-depth interviews were conducted among four focus groups of six targeted participants per group. Semi-structured questions were prepared prior to the interview process. Focus groups were selected based on their exposure to practical work or laboratory environment. Arrangements were made for group participants to be available to participate in the study. Further, field notes were taken during the time when the participants in the study were performing practical work in the Life Sciences laboratory. For focused group interviews, participants were informed about their right to withdraw from the study at any moment. The researcher sought permission from participants to use an audio-digital recorder to record interviews. Secondly, students who participated in the study were observed as the researcher himself is a laboratory technician for Life Sciences Education. Marks obtained from the first and the last practical work as appear in Appendix were recorded for triangulation purposes.

1.7.2.4 Data analysis

Data collected through interviews were coded and analysed through the development of categories, themes and implications generated from the themes identified. Field notes collected during the non-participant observation and worksheets of participants were used to corroborate the information obtained from interviews.

1.7.2.5 Trustworthiness

According to Kumar (2005), trustworthiness of research instruments is the capacity of an instrument to measure what it was intended to measure. Kumar 2005:106) defines trustworthiness as the degree to which the researcher has measured what he has set out to measure. It was crucial for this study to ensure that both interview questions and *in situ* observations were conducted by the researcher while students performed practical work in the laboratory.

1.7.2.6 Ethical considerations

Research is guided by values: the needs and expectations of all the stakeholders targeted in this study needed to be considered. There are certain behaviours in conducting research that affect the ethical sensibilities of every stakeholder. In the process of conducting research, the dangers of compromising such sensitivities need to be avoided by a scrupulously constructed study from the start. Such dangers include the risks of causing harm to individuals, breach of confidentiality, and improper use of information obtained from the study as well as the risk of introducing bias into the study (Kumar, 2005:210). Participants were assured of confidentiality and other ethical considerations as required by the institution's ethics policy, which was adhered to.

Ethical clearance to conduct the study was requested from the university where the researcher was registered for the study. Written consent was sought from every participant in the study undertaken. In the consent form, the purpose of the study was explained, and the role played by each respondent was made clear. A copy of the consent form was given to stakeholders involved in this particular study. Once permission was obtained, arrangements were made prior to the time where interviews were conducted. Anonymity of the institution where the study took place was guaranteed, as well as anonymity of all participating students. Code names for institutions and pseudonyms for individual students were assigned and employed throughout the study. Kumar (2005) states that if respondents are made aware beforehand about information that needs to be solicited, respondents need to be given sufficient time to participate in the study, without any inducement.

1.8. Chapter Division

This study consists of the following chapters:

Chapter One

This chapter presents an overview of the study, including introduction, background to the study, purpose of the study, research aim and research question.

Chapter Two

A detailed synthesis of the relevant literature for the conceptual and theoretical frameworks of this study is provided in this chapter.

Chapter Three

The research design and methodology adopted for this study are discussed in depth in this chapter.

Chapter Four

This chapter draws up summaries of data generated in the process of data analysis. In this chapter data are interpreted within the context of the purpose of the research tools. A synthesis of the findings of the study is presented in the context of the research aims and objectives of the study. Conclusions and recommendation are made.

1.8. Chapter Division

This study is a case study conducted at one university and therefore results might be not use as a norm rather than an attempt for a broader research to be conducted at more universities. Furthermore, dynamics that characterise South Africa differ immensely as some universities are categorised as traditional universities (with their different attributes too) and universities of technology

Chapter 2: Literature Review

2.1. Introduction

Science fields, technology and innovation are essential for 21century educational transformation. In any educational system, citizens must be trained, prepared, and mentored to compete globally. Life Sciences is that branch of science that requires specific methods of teaching and learning skills to enable students to manipulate certain equipment and apparatus and enhance their understanding of a specific topic. Practical laboratory work is a crucial method that enables students to prove theories for themselves and comprehend the actual working of science laws in knowledge construction within a science discipline.

Laboratory practical work gives students the opportunity to accumulate their own knowledge through experiments which they perform by manipulating apparatuses. Studies into the importance of practical work and exploring natural phenomena have been completed by a large number of researchers (Woodley, 2009; Perry, 2015). On the other hand, some researchers criticize practical work as placing too great a demand on the time used for teaching and learning; which impacts on educators not delivering all prescribed work in the curriculum (Killbridge & Teffo, 2014; Rotto & Teffo, 2014; Perry, 2015). In the South African school curriculum, practical work is supposed to be an integral part of the annual learning of science (DoE, 2011). In fact, many schools in South Africa, particularly in rural areas and in townships, lack basic laboratory facilities and many have none at all. In the light of this disconnect between the desired facilities and training of sciences, and the actual conditions at poor schools, this study explored interventions that improve students' preparedness for laboratory environment at first-year level of their pre-service teacher training and development.

2.2 Background to Laboratory and Practical work in teaching and learning of Sciences

Developing countries are routinely associated with wide disparities between social classes: although in real terms so-called developed countries such as Great Britain have class structures with comparable polarities: Oxfam calculates that 86% of Britain's wealth is in the hands of a minority elite of 6% (Woodley, 2009). The cause, however, of wide disparities in countries such as South Africa is not inherited and historical wealth in the hands of an aristocracy or plutocratic minority. Social stratification is, in many cases of developing lands, caused by governments which adopt Western political models in an unquestioning, unreflective way (Bokana and Tewari, 2014; Booyse, Le Roux, Seroto &Wolhuter, 2011). The wholesale adoption of foreign structures or colonial imposition of inappropriate models of government often polarizes a society into classes associated with socio-economic status (Fisher and Scott, 2011; Bokana and Tewari, 2014). Such economic polarization and social stratification may clearly be observed in ways in which secondary and tertiary institutions of education design, implement and evaluate their curricula. South Africa has been particularly vulnerable to this unquestioning adoption of alien ideologies and sustained continuity of systems that have not grown up organically from the historical roots of its own cultures and communities. As a result, citizens are often classified and stigmatized according to their economic/social standing. These social classes have exacerbated the different schooling backgrounds associated with classification of schools within different societal groupings and the quintile system. The South African education system itself, before the democratic era, was harshly divided according to race and social standing of citizens (CHE, 2013; Fisher & Scott, 2011; Booyse, Le Roux, Seroto & Wolhuter, 2011). This division replicated settler attitudes from European motherlands such as England or Holland. The democratic dispensation of 1994 introduced, in theory, equal education for all citizens of the country to redress the imbalances created by the previous regimes (DoE, 1998). Some changes have been successfully made and inequalities in many places have been eradicated but differences in schools are a sore reminder of disparities that persist.

On paper, at least, legislation for democratization of education in South Africa resulted in the transformation of education systems into a single united education system for all citizens. These paradigm shifts were recently referred to as "the education for the 21st century" by researchers in education curriculum (Meyer and Land, 2003). While the system of education changed by act of parliament, however, the practice of teaching at schools and tertiary institutions has not necessarily been transformed from school to school. The division of schools into quintiles has in many ways exaggerated the separations between wealthy and poor schools. The issue of correcting anomalies created by the previous dispensation involved redress of disparities: this process has proved for greater than initially imagined. In practical terms the status and condition of schools and tertiary institutions has stagnated in many instances, especially at poor rural schools.

Wealthy parents of learners, and working-class parents who save sufficient money, prefer to enrol their young at ex-model C schools which are already well-resourced. Some of the benefits these schools offer are: functional libraries and laboratories, as well as qualified teachers to teach disciplinary knowledge to enhance learners' performance in scientific disciplines (Meyer and Land, 2003; Booyse, Le Roux, Seroto & Wolhuter, 2011). Poor schools lack such facilities and their matriculants perform badly. One result of this large distinction between quintile 1 and quintile 5 schools is that a diverse body of students enrol for Life Sciences at tertiary level. Some students have first-hand experience of the laboratory while others have never been inside one; let alone learnt to how to perform basic practical activities such as lighting a Bunsen burner.

The vast majority of poor citizens have had to settle for under-resourced schools with under-qualified teachers who struggle to impart disciplinary knowledge in Life Sciences classrooms due to the absence of Life Sciences laboratories or under-resourced laboratories in many cases (Botha and Reddy, 2011, Meyer and Land, 2003; Booyse, Le Roux, Seroto & Wolhuter, 2011).

The University of Technology, at which this study was conducted, like many other universities in the country, is facing the challenge of enrolling students who come from quite different schooling backgrounds. This study focuses on student experience in conducting practical work in a laboratory environment. Life Sciences as a subject has modules that require laboratory work. At some point Science Education programs require acquaintance with content knowledge depth as well as practical knowledge. This requirement leaves the onerous task of delivering suitable programs in the hands of academics as they have to assist in scaffolding students for what has not been covered at the secondary school to prepare students for further education.

The central question and challenge which this study is designed to meet is the question of how cater for students from such different backgrounds within the same classroom. It has been noted that first-year pre-service teachers in Life Sciences have manifested signs of socio-economic disparities or created by social stratification in the classroom and in laboratory activities. Such manifestations of undesirable classification, as opposed to desirable diversity, create anxiety among those students who have just introduced to working in laboratories and carrying out scientific experiments as required by the university curriculum. Students that have been exposed to laboratory work prior to enrolling for Life Sciences have attended schools where they acquired skills that put them at an advantage compared to those who were not exposed to such. This case still manifests itself even in the decades after democracy to the majority of learners in South Africa (Botha & Reddy, 2011). The difference in schooling environments has been the exclusion or inclusion factor in practical work performed in Life Sciences' laboratories at universities as the curriculum has been designed for specific National Qualification Framework (NQF) levels. Hence, literature reveals that the situation is perpetuated by the inherited differences in schooling systems and therefore explaining these differences in the performance of students in Life Sciences practical work (Botha & Reddy, 2011; Willcocks & Mingers, 2004). Literature asserts that it is crucial for pre-service teachers to be acquainted with the use of laboratories effectively, and to incorporate practical work as part of teaching and learning of Life Sciences to develop adequate Life Science teachers that could end this vicious cycle (Kilbridge & Teffo, 2014; Woodley, 2009:47).

2.3 The significance of practical work in the life science subject

Research has shown that students from the United Kingdom spend more time on practical work than students in any other country worldwide. Trends in International Mathematics and Science Study (TIMSS) have revealed in their study that most teachers in the United Kingdom apply practical work as an integral component of teaching and learning (Woodley, 2009). Woodley (*ibid*) argues that practical work plays an integral part in the teaching and learning of science disciplines because it is integrated in the subject content knowledge. However, in the African continent studies show that there is little progress in improving inclusion of practical work in the science pedagogy. Hoadley, 2006 argues that teachers' attitudes towards practical work are often found to be dismissive as they only do practical work to fulfil minimum requirements of the curriculum. Rotto and Kptigel, (2014) showed that in Kenya students are less exposed to practical work. Perry and Wiewel (2015) states that teachers seldom conducted more than rudimentary repetition of theory work which is a requirement for examination; ignoring the importance of practical work as required in the sciences in a study conducted in schools in Ghana.

In South Africa, in the research conducted in Limpopo showed that teachers made little use of practical work in their lessons. Research into the Science Education curriculum in South Africa shows that South Africa is still a developing country which has been going through a process of radical change in curriculum; from a racially separated education system that existed before democracy (Jansen and Christie, 1999) to one that attempts to provide equal learning opportunities for all. Although the South African education system is regarded as a single system of education, there is still an evidence of division amongst the schools according to quintiles which is meant to address the disparities in the education but it can be argued that it seems to be ineffective and a clear demonstration of existence of inequalities inherited from the apartheid regime (DoB, 2003: 143). The introduction of the quintile system was an attempt to redress imbalances of the past in the education system. Schools that are in Quintiles four and five are mostly ex-white schools which already possess high quality of buildings and grounds and can charge fees. Those schools have adequate facilities to develop their learners holistically. School fees and other funding sources continue to widen the gap between schools with better facilities. Therefore, parents identify such schools as gateways to employment for their children as they are English medium, established and well-run schools.

However, schools in quintiles 1-3 are non-fee schools that depend solely on government funds for them to operate. Such schools lack facilities to improve science learning. In such schools, it seems like the government and parents lack the means to improve them to match standards of their counterparts. This kind of social class division using quintile system in South African schools has exaggerated an already bifurcated system. Learners who attend no-fee schools (Quintile 1-3 schools) have parents from disadvantaged social classes (DoB, 2003: 143). Learners attending schools which charge fees are generally from middle and high-income strata of society (Quintile 4-5 schools), (DoB, 2003). Quintile 1-3 schools cannot afford to have well-equipped laboratories as compared to quintile four and five schools. As a result of the quintile system at primary and secondary schooling levels both prepared and underprepared students enrol for the same courses at tertiary level with the presumption that all students have the same experience of Life Sciences classrooms and Life Sciences laboratories, whereas this is patently not the case. This social class division among South African schooling has led to enrolling students from markedly different backgrounds at tertiary level (Booyse, Le Roux, Seroto & Wolhuter, 2011).

In dealing with first-year students, this study advocates for extra training of learners who had not benefitted from laboratory work in secondary school level. This statement therefore calls for reorganisation of the laboratory teaching to include basic safety measures in a laboratory environment as well as knowledge of how laboratory teaching and learning operates as compared to ordinary classrooms.

Students receive faculty orientation when they reach university level but after the orientation program is completed, the university programs start in earnest and it is assumed, unfairly and incorrectly, that all students are equally familiar with the laboratory when this is not the case; given the gross disparities caused by the quintile system. In the context of this study there has been no culture of orientating students about how laboratory equipment should be used and the assumed safety precautions to be considered when working for the first time in a laboratory environment.

So far at the university at which this study was undertaken, students can familiarize themselves with laboratory equipment and apparatus only when they must perform scheduled practical activities in Life Sciences. Although lecturers start with an explanation of the practical activity, it is the view of this research that unprepared students need to be inducted into how to work or study in a laboratory environment to make up for gaps in their earlier science training (Mwangu & Sibanda, 2017; Cimer, 2011).

Apart from content knowledge of the Life Science discipline, there are scientific phenomena that need to be proven to support theories taught in content through practical work conducted in the laboratory (Kelly-Laubscher & Luckett, 2016; Beisswanger, Schulz, Stenzhorn and Hahn, 2007). Preparedness and under preparedness of first-year students for a laboratory learning environment where they are expected to conduct practical activities is linked to content modules.

2.4 Basic skills for laboratory users

This study bases its investigation on the primary assumption that students enrolling for university are expected to at least have basic skills acquired at secondary school level; such as observation, measuring, manipulation of data, recording of findings, designing experiments, analysing data, and reporting (Ahmat, 2017, Sharma, 2017). Clearly, if a quintile 1 school does not have a laboratory, its school products will not be familiar with any of the aspects listed above.

This study has considered literature produced from studies conducted by the Society of Biology which is a group that promotes biology as a crucial subject to be taught at schools, colleges, and universities (Musante and Potter, 2012). This association promotes the value of delivering biology content and practical knowledge at all levels. This group explains biology as practical science; they hold that high quality appropriate biology experiments and investigation are the key to enhanced learning and clarification and consolidation of theory (Sharma, 2017). The Society believes that practical activities enable students to apply and expand their knowledge and understanding of biology content by conducting investigations that stimulate interest and aid learning and retention. Practical work is regarded by the Society of Biology as a way of helping students to build their own knowledge through experiments and observation to guide them on processes of how knowledge is generated. The importance of practical work in science is widely accepted and such research has acknowledged that good practical work promotes the engagement and interest of students as well as developing a range of foundational scientific concepts (Woodley, 2009).

The Society of Biology defines practical work as a *"key factor in engaging, enthusing and inspiring students, thus stimulating lifelong interest in science high quality, appropriate practical work is the central work to effective learning in science"* (Society of Biology, 2010).

According to the Society of Biology, practical work is believed to help in several ways:

- Stimulates creativity, curiosity, and critical thinking
- Underpins and illustrates concepts, knowledge, and principles
- Promotes student engagement with the scientific method

- Encourages active learning and problem solving
- Allows collaboration
- Provides opportunities to collect and analyse data and apply mathematical skills

Researchers have argued that inquiry is one of the key benefits to be gained from practical lessons. Learning by inquiry is a mode of learning used in the laboratory that has a potential to develop students' abilities and skills. Students are exhorted to pose scientifically oriented questions (Hofstein and Lunetta, 2003; Gunstone and Champagne; 1990). Forming hypotheses, designing and conducting scientific investigation, formulating and revising scientific explanations and communicating and defending scientific arguments enable students to conduct full inquiry investigation on their own (Hamidu., Ibrahim, and Mohammed, 2014; Hofstein and Lunetta, 2003).

Science Community Representing Education (SCORE) explains the importance of practical work; underscoring the good qualities that practical work instils in students because it promotes engagement and interest of students and helps them to develop many skills such as science knowledge and conceptual understanding. SCORE adds that for students to develop all such skills, they have to be exposed to the three categories of practical work: core, direct and complementary activities.

At the University of Technology where this study was conducted, the laboratory serves as a classroom where lectures are held and a place for practical work. Because many students registered for Life Sciences, each level (first year to fourth year) has to be divided into 2 groups. This division results in a high demand for activities to be undertaken at the laboratory. The time available for laboratory work is severely limited owing to the pressure of numbers. Tobin (1990: 105) posits that:

> Meaningful learning is possible in the laboratory if students are given opportunity to manipulate equipment and materials to be able to construct their knowledge of phenomena and related scientific concepts.

As an example of a plant cell compared to an animal cell, students are provided with an onion to cut where they are asked to remove the epidermis tissue to observe the plant cell. To compare animal cells, students are provided with toothpicks to remove cells from inside chicks' mouths. This exercise is simple, but the challenge is the availability of space and equipment for students to observe the differences between the two types of cells. Students who have never used a microscope before taking more time familiarizing themselves with the microscope before even starting with the actual task. When students are required to label structures provided on the drawings, they do not always understand the content knowledge in textbooks which usually assists them to distinguish between plant and animal cells. Some students display confusion in identifying specimens which they need to observe. This difficulty has been regarded by the researcher as a serious obstacle to them acquiring, owning, and successfully assimilating scientific knowledge.

Field trips fit in with practical work in so far as both types of knowledge acquisition encourage the student to observe and learn from their own first-hand experience of the environment. Science can be taught in the laboratory or in the classroom with special equipment, but learners are being presented with a simplified version of the real-world phenomena. Field trips connect a learner's information with the real world. In life sciences there are modules that demand field trips where students can acquire first-hand information. For example, in the third-year program, students deal with a river ecology module. They were required to take samples of water from different sites and measure the temperature of the water at each site. They had to test for the presence of oxygen in each sample of water and at every site. After attending that field trip, students had better understandings about human impact on natural resources.

Researchers from two universities in the UK underscored the importance of practical work and field trips in science education. The aim of science in this case has been seen as means to find explanations that are supported by evidence for events and phenomena in the natural world (Abrahams, Millar, and Whitehouse, 2011).

2.5. Practical work as a Pedagogical tool for Life Sciences Teaching and Learning

Abrahams, Millar, and Whitehouse (2011) argue that the school science curriculum has two distinct purposes which are: aiming to provide every young person with sufficient understanding of science to participate confidently and effectively in modern society and, advancing societal development hence new recruits are needed with high scientific knowledge and expertise. Practical work in Life science has been a pedagogical strategy that invoke inquiry skills which are an essence of what science is, in its nature (Martin-Hansen, 2002; Watson, 1999)

2.5.1 Inquiry Pedagogy

Dewey (1966) describes inquiry as active, persistent, and careful consideration of any belief or supposed form of knowledge depending upon the grounds that support it and further conclusions to which it offers. Inquiry pedagogy involves building hypotheses, searching for evidence, drawing conclusions, and evaluating the strengths of a conclusion. The inquiry process comprises higher order cognitive engagement with knowledge; referred to as critical thinking (Martin-Hansen; 2002). Inquiry pedagogy requires students to pursue their own learning and to participate in the process of knowledge creation; instead of memorizing the scientific findings of another person.

Students who have the advantage of laboratory work are exposed first-hand to processes of scientific inquiry; such students learn to construct conceptual knowledge through a student-designed investigation method (Martin-Hansen, 2002). Construction of authentic knowledge is of greater value than rote learning of facts from textbooks alone. Discovery learning is an inquiry-based method which helps students to be involved actively in investigation, obtaining appropriate information, interpreting causes and effects, and reaching conclusions independently. According to Martin-Hansen (2002), there are different kinds of inquiry. Following her argument, the following elements have been identified.

2.5.1.1 Open or full inquiry

Martin-Hansen (2009) notes that inquiry-based learning is defined as a student-centred approach; allowing students to argue, like the Dialogical Argumentation Model. Students acquire knowledge based on the practical investigation that they conduct; based upon how they investigate, build consensus and gain knowledge independently. This authentically won knowledge is stifled if the educator is not given space to arrive at findings independently.

2.5.1.2 Guided inquiry

This form of inquiry takes place in a classroom context. Through this approach, a teacher challenges student by choosing questions for investigation and by guiding students through a series of questions that provide scaffolding opportunities in the form of practical work. The difference in this case compared to open/full inquiry, is that a teacher assumes the role of mentor; providing mediation between students and knowledge by means of the investigative practical. The teacher becomes a facilitator and a co-learner with the students: students can discover their own novel or unique methods of solving problems.

2.5.1.3 Coupled inquiry

This form of enquiry is described by Martin-Hansen (2002) as a combination of the above-mentioned forms of inquiry. Martin-Hansen states that (*ibid: 35*): "Beginning with an invitation along with the guided inquiry, the teacher chooses the first question to investigate, specifically targeting a particular standard or benchmark". Having embarked on guided inquiry, a teacher reverts to a more learner-centred approach; by implementing an open-inquiry method of investigation. Specific concepts can be explored through a teacher's skills of imparting knowledge; helping students to connect their concrete experiences to abstract concepts.

2.5.1.4 Authentic Inquiry

The National Research Council (1996: 200) showed that the design of instructional environments that involve students in learning about the nature of science is referred to as the scientific inquiry approach. An active learning process in which students are exposed to a practical laboratory environment enables students to develop critical and logical thinking skills. Osborne (1996) argues that the active learning process is the zone where students engage in the process of learning and become responsible for their own work. During practical investigation work, students learn to make their own decisions either individually or in groups while they are given guidance about how investigations are carried out (Watson, 1999).

2.5.2 The inquiry approach to Life Sciences practical skills learnt from a Laboratory environment

Inquiry refers to the work scientists undertake when they study the natural world; proposing explanations that include evidence gathered from the world around them (Martin-Hasen, 2002). This study does not advocate science itself but the benefits (i) of studying science in the laboratory environment and (ii) of teaching and learning science in a specific pedagogy. These benefits grant students the opportunity to transcend learning science from textbooks alone so that they are exposed to practical exercises that develop problem-solving skills and critical thinking. Students engaging in the knowledge production process through problem solving activities that involve proven methods used in scientific learning environments, find ways to identify and solve scientific problems, such as in research done at universities and centres for scientific research. The benefit of laboratory work is that it increases conceptual development through follow-up activities that are tied to the practical activity itself, teaching through the inquiry approach differs from teacher-centred approaches which deprive students of autonomous skills and the capacity to operate at a high level of independent expertise (Hamidu, Ibrahim and Mohammed, 2014).

Hamidu *et al.* (2014) advocate embedding inquiry-cantered laboratories into the teaching and learning taking place in science laboratories; to enhance students' meaningful learning, conceptual understanding, and opportunities to transcend into understanding the nature of science.

2.5.3. Disposition through curriculum

Hoadley (2006) attempts to remove inequalities in schooling systems by looking at reproduction of social class differences through pedagogy. She points out that working class and middle-class students come into school differentially positioned for success. Hoadley (2006) is referring to different positions from entry level of education: these different positions of students' secondary education levels have been observed during this research into the laboratory class of first-year life sciences students. Some students were exposed to laboratory environments at secondary school level; and some were not. This historical inequality accounted for why they are positioned so differently for the laboratory experiments that they were expected to perform.

This observed discrepancy implies that the pedagogy used for some students was different from others; not all had the benefits of practical lessons even if required in their school program. Recent research has elaborated the issue of little or no practical work: most teachers in Africa do practical work in a perfunctory manner merely to fulfil the minimum requirements of the curriculum. Some do no practical work at all; while others repeat theory work that is required for examinations. A few teachers teach science lessons by encouraging memorization of textbook material; instead of investigations, experiments, manipulation of materials and apparatus to promote construction of authentic knowledge (Watson, Kumar and Michaelsen, 2017).

Hoadley (2006) reveals how deep-rooted pedagogy is that it reproduces inequalities of social class in South Africa. Hoadley (2006) explains that orientation to meaning is taken to be the crucial background variable associated with social class. Due to the limited involvement of the researcher in the teaching and execution of practical work, the pedagogy used to teach first-year students could not be explored with any degree of rigor or authority in order to decide the best teaching methodologies. The focus of this research investigation is upon the preparedness of all students for the tertiary laboratory environment. This study argues that orientation to meaning needs to be scrutinized in the teaching of sciences in the laboratory. This orientation to meaning refers to the transmission and acquisition of context-independent meanings and more context-dependent meanings (Sharma, 2017). Studies conducted have shown the pivotal role played by laboratory work in enhancing science teaching and learning in educational institutions (Motlabane and Dichaba, 2013). If students' manifest significant gaps in conceptual and practical knowledge because of their unequal secondary education backgrounds, a pedagogy has to be devised which orientates disadvantaged students to practical lessons in a carefully graduated and scaffolded manner; to bridge the gaps and bring all students up to the same levels.

2.5.4 Bio-mind Curriculum Approach

The notion of a bio-mind approach is a detailed curriculum that corroborates the Inquiry Approach to science education. This study was conducted in an Israeli high school; with the intention of instilling a curriculum that emphasizes the learning *process* rather than outcomes. This curriculum was developed by biology teachers with the aim of enabling students to conduct their own research (Zion, Shapira, Slezak, and Link, 2004). Developing inquiry study activities that emphasise authentic inquiry was recommended for enhancing students' cognitive activities; closely resembling the nature of scientific knowledge and practice.

Components of the bio-mind type of Inquiry accentuate technical and reporting skills: allowing students to (i) formulate hypotheses for themselves, (ii) practise and gain exposure to different procedures which evoke necessary skills of knowledge acquisition, collecting data, and finally to (iii) gain the ability to report findings on their investigation.

Assessments are crucial in promoting practical work for students. Assessments require students to manipulate materials on their own and undertake practical skills and competencies. Assessments are designed to enable students to demonstrate the abilities required for a particular activity. Abrahams, Ress and Sharpec (2013) suggest two methods of assessments of practical skills required from Life Sciences practical work activities: (i) Direct Assessment Practical Skill (DAPS) and (ii) Indirect Assessment of Practical Skill (IAPS). DAPS necessitate feedback to students; sooner rather than later. This feedback from practical work activities is obtained by a student after he or she has been assessed on the specific skills required to demonstrate competency in the practical referred to as IAPS.

According to Needham (2014), there are three aspects that act as a guide to pedagogies for practical work. These entail how students should develop scientific understanding through practical work, through different phases encapsulated practical work as a form of learning science. These pedagogies involve what we know in science, how we get to know what we know, and processes involved in finding how we get to know what we then know. The above aspects justify why practical work should be incorporated into the sciences curriculum.

Science in nature is about exploring phenomena and first-hand experience encourages students to involve themselves in constructing science knowledge, ideas, or theories. Without self-experience it is difficult for students to appreciate or understand science ideas or theories. These ideas can be tested through practical work; especially when students can explore their theoretical knowledge in terms of practical experiments. Experiments are used as crucial components in this process of self-discovery; to assist students to develop and refine their own knowledge. For example, many science students struggle to understand abstract knowledge but through experiments and data collection including evaluation of their own data, students evaluate their understanding of abstract knowledge and create; and build their own knowledge and understanding of science laws, phenomena and concepts.

Students can follow instructions, manipulate equipment and observe processes or phases, and eventually partake in critical reasoning. Students undertake data collection and acquire techniques used in the investigative process which is usually repeated for purposes of establishing accurate results. This process helps science students to answer a basic question which is both ontological and epistemological in nature: how do we find out about scientific ideas, and how do we determine whether they are true or false? At this stage, students acquire fundamental skills and the habits of enquiry which are required for scientific research.

2.6 Theoretical Framework

This study was located within Bourdieu's theory (Bourdieu, 1991; 2005). The diverse backgrounds of students include the social field and the social space that they occupy, contributing to the environment and affecting the relation between knowledge and skills of students. This interdependence influences the coping strategies that Life Sciences students apply in order to increase their scientific, cultural capital and disciplinary knowledge. Scientific capital is described as the disciplinary knowledge that endows Life Sciences students with peculiar skills which are controlled by the environment. Life Sciences students, based on their diverse backgrounds, are differential agents of scientific and cultural capital in the disciplinary field. As agents, they learn to interrogate their own acts of knowledge acquisition and learn to recognise their abilities among peers (Bourdieu, 1991; 2005). The implication of this interrogation is that learning occurs in a graded manner. Students act within the constraints of the rules of a particular disciplinary field; in this case Life Sciences, and gradually learn to question the world around them in an informed and structured way.

2.7 Summary

This review of relevant literature highlights the central concepts that form the basis for supporting data obtained from interviews and in situ observation collected from Life Sciences laboratory activities; in unpacking the impact of first-year students' backgrounds enrolled in a Natural Sciences teacher education programmes at a sampled Higher Education Institution (HEI) in order to explore how different schooling backgrounds impact first-year Life Sciences participation in practical activities conducted in a Life Sciences laboratory.

The importance of background, secondary school experience of laboratory work, is highlighted in the literature reviewed in this study. Bourdieu's cultural and scientific capital have been chosen as a theory best suited to this study. This theory provided a lens to detect themes from the results of the study and to provide perspectives of how the first-year Life Sciences student teachers' backgrounds impact on their abilities or lack thereof to perform investigative tasks that require inquiry-based learning.

Chapter 3: Research Paradigm and Methodology

3.1 Introduction

This chapter presents research paradigms and methods that were chosen and suitably adapted to carry out the empirical study. This chapter outlines (i) procedures adopted to collect data, (ii) the research design, as well as (iii) sampling strategies.

Discussion in chapter 1 indicates that this chapter focuses on obtaining information from participants to answer the main research question outlined below:

What are the factors that influence first-year Life Science students' preparedness for a laboratory environment at University level?

As well as the following sub-questions:

1. What exposure to Laboratory work did the first-year students have prior to enrolling for Life Sciences?

2. How could the students be adequately prepared for Life Sciences practical work?

3.2 Research Paradigm

Most qualitative research in social sciences relies upon an interpretivist paradigm which also suited this study. Literature declares that human behaviour is multi-layered and cannot therefore, be determined by pre-defined probabilistic models since human behaviour depends on shifting situations and unique circumstances determined by environmental factors other than probabilities and quantifiable factors (Henning et al., 2010; Cohen, Morrison and Manion, 2015). Human behaviour is unlike a scientific variable which is relatively constant, predictable, and able to be manipulated but is dictated by complex and changing factors which are mostly subjective in nature. According to Babbie (2014), interpretivists believe in studying human behaviour in daily life rather than in a controlled environment. Hence interpretive paradigm allows researchers to view the world through their perceptions and experiences of participants. The interpretivist researchers therefore use those experiences to construct and interpret their understanding by gathering information. Interviews and observations in this study were utilised to acquire more information about the specific phenomenon investigated, which is first year preservice teachers' preparedness for practical work conducted at the Life Sciences laboratories. Hence, this research project explored factors that influence student preparedness for laboratory work at the University of Technology where this study was undertaken. Therefore, preparedness of first year Life Sciences preservice teachers was investigated through how and why schools were enablers of preparedness of the participants or lack thereof. Gathering information from participants was done in the light of relevant literature that support the choice of an interpretivist paradigm (Miskon, Bandora & Fielt, 2015).

Henning *et al.* (2004) state that a study that seeks to solicit participants' subjective views and perceptions about their environment requires an interpretivist paradigm. Equally, Schumacher and McMillan (2006) substantiate this point of view by stating that an interpretivist paradigm in social research is concerned with what the world means to the person or group being studied and therefore frames the study to consider all aspects about the participants in a research. This paradigm in the empirical study underlines the interaction between the researcher and the participants about their social context (Henning *et al* 2009). Hence this empirical research was conducted in line with the principles of interpretivism where the researcher drew upon the experiences, knowledge, preparedness and individual training of a group of first-year Life Sciences students in a teacher training institution in South Africa. All first-year Life Sciences teacher trainees were invited to participate in the study and the researcher had every opportunity of engaging with, and observing, the first-year Life Sciences as such he was privileged by being involved full-time in setting up the laboratory for experiments, ensuring that everything needed for a practical activity was available.

3.3 Research Methodology

This study employed a qualitative method approach; the researcher explored or investigated factors influencing the preparedness of first-year Life Sciences students for laboratory work who were enrolled for an education teacher's course at the University of Technology. Through qualitative methods, the researcher examined, assessed and recorded complex issues such as ways in which socio-economic status and social stratification impact on the preparedness of these first-year students.

3.3.1 Site selection

The university where the researcher is employed as a laboratory technician was selected as a best possible site since the researcher had unlimited access to participants by the nature of his job to be present and to facilitate each practical activity performed in the Life Sciences laboratory.

3.3.2 Target Population

Welman *et al*. (2005) explains that the population encompasses a total collection of all units of analysis about which the researcher wishes to draw specific conclusions. The sample was derived from the population of all first-year Life Sciences pre-service teachers enrolled for the Life Science sub-discipline of Natural Sciences who were registered for the course in 2018 and being registered for the first time. This was to make sure that participants' abilities had not been enhanced by any experience other than the secondary school experience.

3.3.3 Participant selection

The selection of sample was conducted randomly based on two questions which students needed to answer: Did you have laboratory experience from your previous school? Have you ever been exposed to any practical work in the subject of Life Sciences? These two questions formed stratified random sampling.

Further, documents such as participants' copies of matriculation certificates were requested from participants. Students were purposively sampled; based on the criteria that they either had achieved a high percentage in matriculation Life Sciences or had a lower percentage pass compared to their peers. Secondly, participants had to be involved in practical activities at school (where possible), whether it was through observation or participating in practical activities at secondary school level. The researcher had to distinguish between participants who had laboratories at school or not. Four groups were selected; drawn from students who matched the categories stated above. Three groups comprised first-year Life Sciences students from so-called 'disadvantaged backgrounds' where they were not exposed to laboratory environments whether they had laboratories at their schools or not. Prior to selection of participants, short questions were disseminated to first-year students to inform the researcher of how the samples would look like before they were allocated groups where focused group interviews would be conducted. Participants' roles in the study were made clear in the consent form which was given to all first-year members of the Life Sciences class of 2018. The return rate of participants was good as most of the first-year students wanted to be part of the study, but the researcher had to limit the number of participants to fit the plan of the study.

Below is a Table 1 consisting of homogenous groups formed from the two questions:

Group	**Description of a sample in a particular group**
A	Students who had laboratories at secondary schools and who did practical activities in the laboratory as per the requirement of Life Sciences curriculum
B	Students who had laboratories but were never exposed to any practical activity as required by the Life Sciences School curriculum policy
C	Students who had no laboratories but were exposed to practical work meant to be done in laboratories as stipulated in the Life Sciences school curriculum policy
D	Students who had no laboratories and also never been exposed to any practical activities as required by Life Sciences school curriculum

Figure 1. Categories of sampled first year Life Sciences students from which a sample of six students were selected based on them being keen to participate in the study.

According to Omona (2013), Stratified Random sampling represents a sampling design in which a population is divided into sub-populations such that members of each population that are relatively homogenous with respect to one or more characteristics. The goal of stratified random sampling was to select a sample in such a way that the target subgroups were represented in the sample proportion that they exist in, in the population. All the students who had laboratory experience and had at some time been exposed to practical work formed their group A in Table 1.

The purpose was to probe deeper, to determine what they were doing in that laboratory, including why and how the facility was not used. All students who had access to a science laboratory but were not exposed to any practical work formed group B in Table 1. Group C in Table 1 constituted a sample of six students who did not have laboratories at secondary school but were able to engage in Life Sciences practical activities. The intention was to probe deeper into how they gained exposure to practical work. and finally, Group D in Table 1 consisted of a sample of six students who came from secondary schools that did not have laboratories and were also not afforded an opportunity to do practical work. The intention of this group was to probe deeper into how these students were taught the practical part of Life Science curriculum.

All these homogenous groups were given 30 minutes of unstructured interviews and an audio-video was taken. Therefore, qualitative methods in the form of a case study was adopted for the collection data. The researcher obtained biographical information from students who participated in the study.

Pseudonym	**Gender**	**Race**	**Type of school**	**Resources for teaching Life Sciences**
A1	Female	White	Private School	Exceptionally good labs, classes & excellent educator
A2	Female	Black	Private School	Incredibly good resources but teacher relied more on slides
A3	Female	Coloured	Ex-model C school	Good laboratory & teacher

A4	Female	Black	Ex-model C school	Good Life Science class with storeroom for equipment & good teacher
A5	Male	Coloured	Ex-model C school	Well-resourced laboratory & excellent teacher
A6	Female	White	Ex-model C school	Well-resourced lab with a great teacher

Table 2: Biographical information of students who participated in the study in Group A

Pseudonym	**Gender**	**Race**	**Type of school**	**Resources for teaching Life Sciences**
B1	Female	Black	Rural school	Laboratory is there but not used for teaching science
B2	Female	Black	Township school	Well-resourced laboratory but not used for practical work
B3	Female	Black	Township school	Laboratory used as a storage place
B4	Female	Black	Rural school	Good Life Science class with storeroom for equipment & good teacher

B5	Male	Coloured	Township school	Poorly resourced laboratory but good teacher
B6	Female	Coloured	Township school	Well-resourced laboratory is used as a Life Science classroom, but no experiments done

Table 3: Biographical information of students who participated in the study in Group B

Pseudonym	**Gender**	**Race**	**Type of school**	**Resources for teaching Life Sciences**
C1	Female	Black	Township school	No lab but teacher borrows equipment from other schools
C2	Female	Black	Township school	No laboratory but teacher gives us worksheets
C3	Female	Black	Township school	No laboratory but practical is done
C4	Female	Black	Township school	No lab. but school takes us to schools that have resources
C5	Female	Coloured	Rural school	No lab but teacher takes good learners to schools in town

C6	Female	Coloured	Township school	No laboratory but teacher borrows from other nearby schools in order for us to do practical

Table 4: Biographical information of students who participated in the study in Group C

Pseudonym	**Gender**	**Race**	**Type of school**	**Resources for teaching Life Sciences**
D1	Male	Black	Rural school	No laboratory but teacher uses question papers to explain practical work
D2	Male	Black	Rural school	No laboratory but teacher explains how the practical is done and we take notes
D3	Male	Black	Rural school	No laboratory, teacher explains and then gives us worksheets to answer questions on practical work
D4	Female	Black	Rural school	No labs were present, but teacher used textbooks to explain how they were done.
D5	Female	Black	Rural school	No lab, teacher used textbook and past years'

				question papers to explain practicals.
D6	Female	Black	Rural school	No laboratory but worksheets with experiments were explained to us.

Table 5: Biographical information of students who participated in the study in Group D

iv. Data collection

3.3.4.1In-depth interviews

In-depth interviews were conducted in four focused groups of six targeted participants per group. Semi-structured questions were prepared prior to the interview process. Focused groups were selected based on their background of exposure to practical work or laboratory environment. Arrangements were made with group participants who were keen to participate in the study and who were available to participate in the interview process at the time scheduled for a group.

3.3.4.2 Participant Observations on practical tasks and Analysis of data obtained write-up of practical work tasks given to first year Life Sciences Education students

For purposes of triangulation that assisted the data obtained from interviews to be trustworthy, non-participant observations were done; to study the case and in order to ascertain reliability of data so that data obtained provided a true reflection of the circumstances around the case being investigated. In this way findings and conclusions obtained from this study could be duplicated elsewhere (Babbie & Mouton, 2009).

Microscopes are irreplaceable equipment for Life Sciences discipline laboratories and as such Kara (2018) regards them as the window to the world of microorganisms. Microscopes enable the human eye to screen the micro-world and study microorganisms, and other micro level substances. Kara suggested that this provides an opportunity to wonder at, examine and investigate the complexity of the body system at a cellular level. Kara (2018) elaborates on the importance of microscopes in different professional sectors; because they enhance knowledge in so many areas: biological, medical, geological, agricultural forensic etc. In all these sectors, students need to be introduced to microscopy by acquiring the first basic skills.

At the university where the study was conducted, participants were expected to be able to use microscopes. The curriculum states that learners are supposed to be introduced to microscopes at grade 10. A Life Sciences laboratory technician introduced the whole group to microscope parts and functions of each part. He demonstrated how to prepare their own slides and observe them using laboratory terminology, plain slides, cover slips, objective lenses, ocular, stage, main adjustment, course adjustment were basic techniques. Observation took place at the first microscopic practical which they were supposed to do for the term. The practical was on plant and animal cell theory to distinguish between plant and animal cells. The groups were provided with piece of an onion and were instructed to extract the epidermis of an onion, mount it in the plain slide and observe it through a microscope.

Field notes were taken while participants were performing practical work in the Life Sciences laboratory. Students were left to continue working as groups that were sampled for the study together with the rest of the class.

Later in the year, the same first-year students were once again exposed to another activity involving the use of microscopy. They were required to mount prepared slides of a dicotyledonous stem on the microscope; first at lower level magnification (4X) and again at a higher magnification (10X magnification). They were asked to draw the structure of the dicotyledonous stem, provide its labels and to answer questions based on the information linked to the content taught prior to the experiment in order to demonstrate appropriate application of content knowledge to practical knowledge.

Students were allocated two practical investigations to link the topics of energy and metabolism and secondly a practical on diffusion and osmosis; to discover how they are linked to everyday life.

The energy and metabolism practical was designed to demonstrate how students were able to use inquiry skills to explain the rate at which a peanut and a raisin took different rates of consumption when they were burnt; and to explain the relation between varying temperatures between the initial temperature taken from heating up a peanut and a raisin, to their final temperature after heating the two food items.

Similarly, students were given pieces of potato to record their initial mass before they were immersed in water (control) and other pieces in a salt solution (experiment). Students were instructed to weigh potatoes in intervals of five minutes apart. The students were encouraged to apply inquiry skills to demonstrate the process of osmosis. Students were encouraged to present their findings in the form of tables and graphs, and to demonstrate linkages between content taught about the two phenomena and application of that knowledge to the practical tasks given.

The researcher made observations of first-year Life Sciences' development between two related practical activities; given that the first two sets were submitted during the first semester of the academic year and two were submitted in the second semester. The purpose of the two related tasks in the first and second semester of the year was to demonstrate the different levels of student preparedness for a laboratory environment.

3.3.5 Data analysis

Data collected through interviews were coded through an open coding system and themes were generated from the coded transcripts to guide the researcher about the extent at which such themes constitute findings of the empirical research conducted. The data was analysed through categories, themes and findings were generated from the themes identified. For purposes of triangulation of data obtained through interviews, data obtained from in situ observations were used to explore what the interviews missed and vice-versa. Both sets of data were used to generate findings of the study. Furthermore, the performance of students in each task was meant to strengthen the findings of the study and to demonstrate the importance of students' preparedness in doing practical work. The above aimed at supporting the aim of the study.

3.4 Trustworthiness

According to Kumar (2005), trustworthiness of research instruments is the capacity of an instrument to measure what it was intended to measure. Kumar (2005) defines trustworthiness as the degree to which the researcher has measured what he has set out to measure. It was crucial for this researcher to ensure that (i) both interview data and most importantly *in situ* observations were undertaken by the researcher as students performed practical work in the laboratory and (ii) that document analysis was done on practical write-up activities done by first-year Life Sciences students.

3.5 Ethical considerations

Research is guided by values: the needs and expectations of all the stakeholders targeted in the study needed to be considered. There are certain behaviours in conducting research that inform the ethical consideration of every stakeholder in the process of conducting research that need to be built into the study from the start: e.g. the risks of causing harm to individuals, breach of confidentiality, and improper use of information obtained from the study, as well as introducing bias into the study (Kumar, 2005:210). Participants were assured of confidentiality and other ethical considerations as required by the institution's ethics policy, which was adhered to.

Ethical clearance to conduct the study was requested and obtained from the university where the researcher was registered for the study. Written consent was sought from every participant in the study undertaken. In the consent form, the purpose of the study was explained and the role to be played by each participant was made clear. Once permission had been obtained, arrangements were made prior to the time where interviews were to be conducted. Anonymity of the institution where the study was undertaken was guaranteed as well as anonymity of participating students. Code names for the institution and pseudonyms for individual students were used throughout the study. Kumar (2005) further argues that if respondents are made aware beforehand about information to be solicited, respondents need to be given sufficient time to participate in the study, without any inducement.

3.6 Summary

This chapter outlines how the research was conducted from the selection of an interpretivist paradigm and how it suited the empirical study. This study assumed a qualitative approach to collect data that was aimed at answering the two research questions of this study. Purposive sampling strategy was used to select participants and three data collection methods were used for triangulation purposes. Ethical considerations were addressed by ensuring the anonymity of participants and adherence to university ethical clearance principles.

Chapter 4: Presentation and Discussion of Results

4.1 Introduction

This chapter presents a systematic analysis of data collected by means of in-depth interviews and analysis of documents. The process of data analysis commenced soon after all documents were obtained, and interviews were completed. Transcripts were developed from audio-recorded responses and raw data were coded manually. Classification of data followed themes were identified. The findings and implications generated during data analysis were categorised and presented under each theme. Data was analysed by means of qualitative procedures discussed earlier.

4.2 Responses of participants from focus group interviews

Theme # 1: First-year students revealed disparities emanating from their divergent socio-economic backgrounds.

Understanding different backgrounds of these students allowed the researchers to detect anxiety in some group of students when they conducted practical experiments at the Life Sciences laboratory. Others seemed relaxed. But the language they use in naming laboratory apparatus has been seen by the researcher to be a common language; based on description of apparatus the way they see it. Some students in the first-year Life Sciences class described a coverslip as a small glass; plain slide as its glass and a beaker as that thing we use for water. Similarly, in focus groups interviews, several participants made utterances that revealed significant disparities in laboratory experience such as:

> “There was a lot of things when we started our first practical, there were lot of apparatus I didn’t know what it was, and I didn’t know how to use it as well. So that’s where the problem comes in because our school was under-resourced”.

Another participant reported:

> “My first time to see was this year doing the first practical for the first time, we did few things like beakers, but we didn’t have all the different equipment. This has made me to be ashamed to ask from my classmates due to the fear of embarrassment”.

While yet another participant stated:

> “I had a microscope at home that my parents bought for me when they discovered how curious I was when it comes to scientific phenomena, I saw from the discovery channel in the DSTV. My school had a laboratory with a laboratory technician who assisted sir to explain practical work conducted”.

The purpose of the stance or strategy of categorizing students into the four groups based on their experience of practical laboratory work at secondary level and experience of working in a laboratory environment was to assist the researcher to focus on where students stand academically in relation to laboratory work and to determine their level of effectiveness in conducting practical investigative tasks for Life Sciences knowledge and skills acquisition at university level. The schooling background contributes to how soon students can adapt to the new environment. Experts who deal with education programs at universities need to deploy various pedagogical strategies to cater for the variety of students.

Students who show anxiety in the laboratory environment, due to a lack of exposure at secondary level, need more support from senior students, laboratory technicians/assistants and subject lecturers.

Findings:

Data from focused groups interviews demonstrated that there are several factors pointing to significant disparities amongst first-year Life Sciences students. Data obtained from practical activities through observations and analysis of students' practical write-up of activities and results obtained from the four activities used in this study, were all designed to answer two pertinent questions of this research. These were:

- Did you have laboratory exposure at your previous school?
- Were you exposed to any life science practical activity?

Results showed that first-year Life Sciences students at university have widely differing experiences and levels of exposure to laboratory environment. The challenge is for the university curriculum which assumes, incorrectly, that students are drawn from equal schooling backgrounds and exposure to practical work and exposure to laboratory environment; placing a high level of demand on students according to NQF levels demanded by curriculum standards.

The program for Life Sciences includes both theory and practical work followed by subject curriculum studies. Data from interviews showed that some students have never been exposed to any practical lessons in a formal science laboratory, while some were only exposed to observation but were never able to manipulate apparatus or materials themselves to engage in inquiry activities. Other students came from well-resourced schools and were ready to perform practical activities;

their prior exposure to laboratory environment and to practical activities enabled them to outperform others from disadvantaged schools. This disparity explains the frustration in certain group of students and advantage for another group of students.

Students in category one represents first-year Life Science students from well-resourced schools. These students are from different backgrounds because schools in South Africa are divided according to harsh socio-economic divisions based on income and residence of their parents. The students who have parents that afford to provide their children to attend well-resourced schools classified as quintile 4 and 5 in the South African schooling system are in a better position for earlier exposure to studying Life Sciences knowledge and investigative skills that require laboratory activities; far more so than those from those schools at lower quintile levels where lack of resources for adequate teaching and learning of Life Sciences education is an issue.

The idea of quintiles in South African schooling system was originally born from a desire for social justice, yet the system is seen in this study as a perpetuation of social stratification in the nation (DoE, 2003). Looking at the South African context of this study there is a notable congruence with Bourdieu's model of capital conformation; of how organizations plan and position themselves in a different context in order to ensure their types of capital are enjoyed by and benefit those who are within their social grouping. In the South African schooling system, the poor are systematically marginalized while those who can pay education for their children enjoy all the benefits; while those who cannot are pushed into no-fee schools. Equal education was the dream of our liberation.

4.2 Data Acquired through In Situ Observations during Practical work classes (Use of Microscopy in the Laboratory)

Observations were conducted into first-year Life Science Education students during first activity of life science practical work. The first observation made was that these students grouped themselves according to the language they speak with each other. All those from model C schools grouped themselves together. They spoke English to each other in their conversations. All those who were not comfortable with speaking English formed their own groups as well; some were Xhosa speakers some Afrikaans speakers. Bourdieu explains symbolic capital as one of the forms actors possess. In the Life Sciences laboratory, students demonstrated different levels of preparedness for laboratory activities. Most students showed the fact that they are knowledgeable, when it came to conceptual knowledge on explaining phenomena being investigated through practical activities, they displayed depth of understanding and explaining concepts that were used in the pre-practical and post-practical activities. This ability is explained by Bourdieu as growth in scientific capital (Bourdieu, 1999). This performance shows why most students obtained higher marks in these practical activities as demonstrated in two tables above which reveal the number of students who obtained higher scores from practical activities. When the randomly selected practical write-up of these activities was analysed, the point of different abilities came out strongly; displaying that most students lacked drawing skills and labelling of structures appearing on both the plant and animal cells they drew later in the year, the structure of a dicotyledonous stem.

Some students drew structures that they thought about from images they had seen in books, not understanding that the type of microscopes they used would give them few detailed structures because cell structures drawn in textbooks were adopted from images taken from advanced microscopes such as more sophisticated light microscopes that were available at the university laboratory and some images from more sophisticated electron microscopes which are not easily available at university level. Few universities possess a single electron microscope and such were used for advanced anatomic structures of plant and animal cells, tissues and even organs as in the case of a practical on Dicotyledonous stems, where detailed and intricate cell and tissue types could be observed at 40x magnification. The instruction that students were given was to observe a specimen on the lowest magnification (4x objective lenses) before zooming images to a higher magnification (10x objective lenses). The purpose of giving students that instruction was to help them observe the overall structure of a plant stem before turning to higher objective lenses (10x objective lenses) in this activity. However, it was observed that on the second practical activity on microscopy they were relaxed and more confident compared to a practical that was given them on plant and animal cells to draw under the microscope.

It was appreciated from observations that the second time around all students eagerly participated in the activity and engaged on inquiry-based activities. When these students were first given opportunities to do these practical activities on their own not all students knew how to use a microscope and many lacked confidence to draw what they saw in a specimen rather than what they already obtained from book knowledge. In their second task on microscopy, however, few students drew what they had in their minds of what the specimen should look like. Mostly, their microscopic hands on skill had improved as well as their drawing and labelling skills. This growth in skill is explained in depth in the literature review chapter where cumulative knowledge was explained. (Bourdieu, 1999). Bourdieu in his notion of social capital explains capital to include both material and immaterial availability of resources. At the university where this study was conducted, students were observed to be from schools where the lack of material resources to teach life science was a key concern; where some students were taught the subject with no resources at all.

Some authors explain capital as observed where actors possess different amounts of knowledge, skill, education, qualification (Martin-Hamsen, 2002; Woodley, 2009; Killbridge &Teffo, 2014; Rotto &Teffo, 2014). In the laboratory situation, students from former model C schools were observed using equipment (like microscopes) and apparatus without hesitation and with ease; while those from inadequately resourced schools were observed to be struggling; trying to familiarize themselves with the equipment before doing the actual task. Even though the researcher had taken them through the microscope's features to explain each part and how it is operated, such students still struggled to work with the equipment on their own.

In observing different backgrounds of students, the researcher noticed the acute and predictable anxiety that some students felt when they were expected to conduct practical activities at the Life Sciences laboratory for the first time. Others seemed relaxed. Yet some novice students could name laboratory apparatus: these students had first-hand experience of laboratories, while others only knew about apparatus from reading science textbooks. Many students were asked to describe objects in the laboratory and were unable to do so: for example, a coverslip was considered to be a small glass, a plain slide as its glass, a beaker as a utensil for holding water. It became apparent that first-year Life Sciences students had widely varying levels of familiarity with laboratory equipment and abilities in performing laboratory practical activities. The pedagogy of training and developing Life Science pre-service teachers assumes familiarity with knowledge domains of scientific knowledge (Killen, 2015). Students' obvious lack of knowledge of terminology when performing practical activities became clear. Few students met the Minimum Requirements for Teacher Education Qualification (MRTEQ), (DHET, 2018).

They also had shown confusion on what they actually observed on the specimen. The technician helped them to reach the right focus, but students were drawing from nothing to construct knowledge. The aim of the task was to show them the differences between animal cells and the plant cell. When they observed the microscope and observed objects, where they were not fully familiar with, they tended to hesitate as to whether what they drew was right or wrong. Students moved from table to table to ensure that what they saw was the same as what others saw before they made a drawing. This showed that these students were unsure. Those students from well-resourced schools were comfortably observing and making drawings and proceeded to the next activity. Those students were observed to be in groups that submitted their complete tasks on time ahead of the other students.

Findings:

At the university where the study was conducted, life science students are trained to be able to teach life science and natural science upon completion of their degree. Therefore, these students need to be scaffolded by their teacher-educators and all relevant stakeholders to attain levels of competence which assist them to teach Life Sciences adequately and with confidence. The second microscopic activity showed that students had the potential to learn new things when they were offered some patience and guidance by those who knew so that they could then join the community of knowers (Hoadley, 2009).

Theme 2 First year Life Sciences students displayed different choices of groups based on dynamics emanating from their schooling backgrounds

Observations made by the researcher indicated that students from similar schooling backgrounds would gravitate towards one another; based on competency in language of teaching and learning and the knowledge of scientific terminology used in the laboratory. Students from ex-model C schools, (black, white and coloured) would easily form groups that demonstrated where they were from, whereas those other students from township and rural schools formed their own distinct groups. It was noticed that some students from schools where Afrikaans was used as medium of instruction formed their own group within the same class.

In keeping with the literature reviewed, results highlighted issues of socio-economic inequality. Information was obtained from this synthesis of literature as well as the choice of theoretical lenses used in synthesising data obtained from both interviews and in situ observations. Bourdieu's (1999) social capital and scientific capital theories were selected as lenses to view the study. The way students operated in the laboratory, how they shared knowledge and how they began to involve one another in the tasks, suggested that they moved from a point of being stuck to their social experiences to adapt into a new way of learning science hence building their scientific capital.

Meaningful learning processes and group dynamics, and elevated scientific and social capital were acquired as students worked together. Semantic gravity began to increase from less negative to positive; the more the laboratory was open for students to be involved in more inquiry and problem-based learning activities. When students were exposed to activities which invoked creativity and inquiry, there was a discernible increase in learning and performance with the demonstration of good to excellent performance in practical assessments.

Findings:

Based on the way first-year students improved, teacher educators involved in teaching these students, together with the researcher, noted that there was an appreciable improvement in students' confidence and attitudes towards involvement in laboratory practical activities. The role of the researcher changed from that of administrator to being a participant in the teaching. The learning process in the laboratory allowed learners to overcome the fear and anxiety of being labelled as "stupid" to taking ownership of their learning process through a participative approach. This growth was consistently reinforced by the researcher's belief that every first-year Life Science student had to start from somewhere. If they found challenges emanating from knowledge and skill gaps, help was not far away. Doing practical laboratory work and linking practical to content knowledge skills allowed them to move ahead, from where they were at secondary school level, a position of not having been exposed to practical work and a formal laboratory environment to where they could act without any fear of the unknown and anxiety observed at the beginning of the study. This notion resonates well with inquiry-based learning as discussed in chapter 2.

What was seen as varied students' backgrounds initially associated with social class slowly began to disappear; compared to the initial stage where students were exposed to five practical investigative types of work in the laboratory.

Theme 3 First year Life Sciences students displayed that their schooling backgrounds did not interfere with their performance in laboratory work and task linked to practical activities.

Participants	**Pract 1**	**Pract 2**	**Pract 3**	**Pract 4**	**AVERAGE**
A1	74	68	83	88	78
A2	70	61	76	74	70
A3	77	57	70	77	70
A4	65	68	67	81	70
A5	72	70	78	75	74
A6	70	66	72	70	70
B1	76	64	76	80	74
B2	63	66	65	74	67
B3	58	67	78	76	70
B4	75	59	72	81	72
B5	68	64	69	70	68
B6	79	70	73	83	76
C1	62	67	63	72	66
C2	70	65	71	75	70

C3	65	59	67	70	65
C4	74	65	71	76	72
C5	69	60	74	70	68
C6	78	69	80	86	78
D1	59	55	61	70	61
D2	54	51	56	63	56
D3	62	66	72	78	70
D4	59	65	69	72	66
D5	63	58	71	69	65
D6	67	58	65	71	65
Pract. Av.	68	63	71	75	69

Table 6: The performance of participants in tasks that was performed following practical activities that were conducted in the laboratory. Each participant mark is expressed in percentage and the average mark taken from the four tasks per participant is presented in the last column. In the last row, the average mark (mean) of each task is presented.

Results in Table 6 when compared to participants' biographical information demonstrated that no matter which category the participants were, they performed reasonably well. The column illustrating their performance over time that there was no significant difference in performance whether students came from well-resourced school or schools with no resources. Even though this might be the case in this study, ideally equal opportunities are desired to yield better performance.

These students could have motivated each other and utilised the resources given to them to succeed in their tasks. Hence, those students who came from disadvantaged backgrounds could have realised that they need to put more effort in the practical activities performed at the labratory while other students could have taken for granted the fact that they are knowledgeable in the activities, laboratory setting and did not apply much effort and did not utilised the help available as other students did. These results can be explained by the fact that if Social Capital improves, there are better chances of students moving from perceiving that practical work done at the laboratory is difficult and a source of anxiety, to where they see such work as an opportunity to explore and engage in scientific discovery processes. Consequently, the results unearthed a growth in scientific capital as suggested by Bourdieu's theory (Bourdieu, 2005).

Findings:

The findings of this study were in agreement with results of studies conducted by other researchers in similar contexts that have shown the pivotal role played by laboratory work in enhancing science teaching and learning in educational institutions (Motlabane and Dichaba, 2013). Students from vastly different socio-economic backgrounds were exposed to different Life Sciences subject pedagogies requiring practical lessons as expected in the nature of the discipline: students from deprived backgrounds displayed at first the adverse effects of exclusion and deprivation to a position of inclusion; mapping growth in ontological and epistemological aspects of their discipline.

4.3 Limitations of the study

Even though the focussed interviews were preferred as a data collection, the researcher's weakness was on how the transcription was done and ended up writing summary of what the participants stressed on. Some of the information has been presented in the tables that detail participants' biographical information. Consequently, generalisation cannot be made on the findings of the interviews. However, the observations made during practical work session and the way practical work activities are presented made up of the weakness of the first data collection method. Analysis of practical work provided insights on individual participant's performance.

4.4 Conclusions and Recommendations

This study revealed clearly that there are indeed gaps between students from the two schooling backgrounds: upper and lower quintile schools. Another major finding of the study was that students displayed variable skills and conceptual understanding which agreed with Bourdieu's theory of social capital and was seen in this study as contributing to scientific capital. It was further concluded that absence of exposure to resources needed to conduct practical investigations had an impact on students who were doubting themselves when conducting practical activities.

When guided inquiry was used as a strategy to engage students in doing practical laboratory work, results obtained from practical activities did not differ much from the results obtained by students from well-resourced schools. Students obtained similar results when they were given a complex practical activity (plant tissue microscopic activity) at the end of the year. This study underscores the need to understand that there are different backgrounds in knowledge among students when they come to university from secondary schools. A baseline assessment needs to be administered to students to create a picture of competence in fundamental practical skills such as drawing skills, labelling skills and engaging students on activities that challenge them to engage in inquiry-based learning.

Early detection of knowledge and skills gaps among students doing first-year Life Sciences practical work could equip students with the skills that they need; especially when various scaffolding methods are applied to make up for disparities. Laboratory learning requires pedagogies that ultimately allow students who were struggling to become better achievers. It is further recommended that schools need to be consistently checked to ensure that practical work prescribed in the school curriculum is being done: curriculum advisors should be made aware of conditions of lack of resources and teachers to conduct the practical work prescribed. Once students are exposed to inquiry-based teaching and learning, skills such as critical thinking are likely to come naturally on them.

Furthermore, if students were to be grouped so that they assume a variety of categories in this study and their work being carefully monitored, students could better scaffold one another in groups.

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