HOW PREPARED ARE FIRST-YEAR LIFE SCIENCES PRE-SERVICE TEACHERS FOR THE LABORATORY LEARNING ENVIRONMENT? A CASE STUDY AT A UNIVERSITY OF TECHNOLOGY

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Abstract

Developing countries are routinely associated with wide disparities between social classes have often been observed in developing countries such as South Africa. Such social stratification is in many cases caused by governments who adopt ideologies from well-developed countries without reflecting upon the context in which such ideologies are to exist. The University of Technology, at which this case study was conducted, typifies the inequality in social classes from which students are drawn. This study aimed at focusing on student experience in conducting practical work in a laboratory environment. A purposive sampling strategy was chosen with the aim of investigating the effect of prior exposure of first-year Life Sciences students to the laboratory environment. Life Sciences in its nature require students to be acquainted with both content knowledge and practical work knowledge. In identifying preparedness of first year Life Science for university education, it has been observed that these students have manifested signs of socio-economic disparity in execution of practical conducted in laboratory environments. The researcher observed manifestations of these differences in laboratory practical activities: such as microscopic, taxonomy, measurement skills required as knowledge learnt prior to their enrolment in education. This study was underpinned by Bourdieu's, scientific capital and cultural capital as well as Maton's Legitimation Code Theory. Such theories address disciplinary knowledge that endows Life Sciences students with peculiar skills: lacking or debilitated by poor secondary school training. Results of this study revealed that there are indeed visible differences in the way that students executed selected Life Sciences practical activities introduced in the Life Sciences laboratory. Such discrepancies were relatable to differences in schooling. Some students were drawn from schools where practical activities were not conducted while other groups of students in the sample for this study were adequately prepared to conduct experiments independently. This study concluded that South African academics need to be more aware of the social dynamics.

Keywords: Different social backgrounds, Laboratory, Life Sciences Education, Practical work, Pre-service teachers.

1 BACKGROUND

The South African education system, before the democratic era post-1994,, was fragmented according to race and social standing of citizens (CHE, 2013; Fisher & Scott, 2011; Booyse, Le Roux, Seroto and Wolhuter, 2011). The democratic dispensation introduced equal education for all citizens of the country; to redress imbalances created by the previous regimes. (DoE, 1998) is assumed in this study to have made some changes but differences in the schooling contextual background cause disparities that persistently remind us of the extent of the damage inflicted by the previous dispensation upon the schooling system in South Africa.

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 entirely. Correcting anomalies caused by the previous dispensation involved redress of disparities between schools. This process has proved for greater than initially imagined. The status and condition of schools and tertiary institutions have stagnated in many instances.

The University of Technology, at which this study was conducted, like many other universities in the country, is facing the challenge of enrolling students drawn from very different schooling backgrounds. This study focuses upon 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, and immersion in, content knowledge as well as practical knowledge. The discipline requires foundational knowledge which should be acquired at a secondary education level. In many cases secondary schools have failed to equip learners with such knowledge; leaving the task of delivering suitable programs in the hands of academics. The central point of enquiry in this study is concerned with designing university programs that cater for students from widely diverse backgrounds. First-year pre-service teachers in Life Sciences have manifested worrying signs of socio-economic disparity or stratification in the classroom and in laboratory activities. Such manifestations of classification, rather than diversity, arouse anxiety among those students just introduced to working in laboratories and carrying out scientific experiments as required by the discipline. Other more privileged students received initial exposure to laboratory work because they attended schools where such exercises were performed in school laboratories by skilled teachers. This is not the case for the majority of learners in South Africa (Botha & Reddy, 2011). The difference in schooling environments has been seen as the exclusion or inclusion factor in practical work performed in Life Sciences' laboratories which are the integral part of science education. The results of the inherited schooling differences have seemed to be a contributing factor in the performance of students in Life Sciences practical work (Botha & Reddy, 2011; Willcocks & Mingers, 2004).

International research has shown that students from the UK spend more time on practical work than in any other country world-wide. The International Mathematics and Science Study (TIMSS) has revealed in their study that most teachers in the United Kingdom apply practical work as an integral component of teaching and learning. Woodley (2009: 49) states that practical work plays an integral part of their pedagogy; as they do not separate it from content of the subject. However, the research revealed that the African continent is not doing well on improving their practical lessons as an integrated aspect of pedagogy. Kibirige and Teffo, (2014) argue that the teachers' attitudes towards practical work are often dismissive: they only do enough practical work to fulfill minimum requirements of the curriculum. In South Africa, Dekker 2005 revealed on his research conducted in Limpopo that teachers conducted little practical work on their lessons. Rotto and Kptigel, (2014) demonstrated that in Kenya students are less exposed to practical work. Perry (2015) states that teachers seldom conducted anything more than rudimentary repetition of theory work required for examination purposes; ignoring the importance of practical work as required in the sciences disciples in the study conducted in schools in Ghana.

This study assumes that students enrolling for university are expected to have basic skills acquired from high school; displaying exposure to laboratory activities: observation, measuring, and manipulation of data, recording of findings, designing experiments, analyzing data and reporting. The study investigates 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 through actively involving students to do practical work in Life Sciences. It is in this light that the main research question for the study can be posed as:

- What is first-year Life Sciences students' preparedness for the laboratory environment at university level?

The following sub-questions will 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 be addressed?

Killen (2015) observes students' lack of knowledge of terminology needed by first year Life Sciences students to be fully or partially acquainted with the laboratory environment when performing practical activities required in the university curriculum.

2 LITERATURE REVIEW

Laboratory work plays a distinct and central role in the science curriculum. 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 experiments and to critically analyze results have been the key purpose of exposing Life Sciences novice teachers in laboratory practical work. In support of the above, Momlok-Naaman.and Barnea, (2012) claim 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. In order for students to possess all or most of these skills, students need exposure to the 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 Life Sciences educators.

Hodson (1990) criticizes some practices in executing laboratory work by claiming that it is unproductive and confusing due to lack of proper planning. The above statement insinuates 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 to be used have been tested. This is done to ensure that time for the investigation to be undertaken is not wasted through poor planning. Everything has to be prepared in order to enable the students to focus on the task to be undertaken. This attention to planning reduces pressure on the person who is to instruct and facilitate the investigative exercise: s/he 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 the culture of scientific enquiry.

The literature shows that at some schools that have laboratory resources, there is evidence of inadequate or improper use of laboratory resources (Syh-Jong, 2007; Bone and Reid, 2011). This neglect could defeat the purpose of the Life Sciences discipline: laboratory practical work is necessary to impart inquiry skills as well as gain 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 knowledge through science practical work, a lived experience which enables students to practice, think and act like scientists. Tobin states that meaningful learning is possible in the laboratory if students are given opportunities to manipulate equipment and materials in order 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 in order to initiate and encourage discussions within the learning environment.

Not all activities in the laboratory will be appealing to all students. An instructor must develop activities in such a way that gives 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).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). The 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 through book knowledge alone. Students engaging in laboratory work find ways to identify and solve scientific problems. The benefit of hands-on experience is that conceptual development is facilitated through follow-up activities tied to the practical activity they are involved in. Teaching by using the inquiry approach differs from the teacher-centered approaches to teaching and learning which deprive students of skills and capacity to operate at a high level of expertise (Hamidu, Ibrahim and Mohammed, 2014).

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

According to Hamidu *et al*. (2014) the Society of Biology is the group that promotes biology as a crucial subject to be taught from schools, colleges and universities. This association does not only promote the subject but they also look at delivering biology content and practical knowledge at all levels. This group explains biology as practical science: high quality appropriate biology experiments and investigation are the key to enhance learning and clarification and consolidation of theory (Momlok-Naaman and Barnea, 2012; Hamidu, Ibrahim and Mohammed, 2014). They believe that practical activities enable students to apply and expand their knowledge and understanding of biology content by doing investigations that stimulate interest and aid learning and retention. Practical work helps students to build their own knowledge through experiments and observation and engage in processes of how the knowledge is generated. The importance of practical work in science is widely accepted and research has acknowledged that good practical work promotes the engagement and interest of students as well as developing a range of science knowledge (Woodley 2009).

The time for laboratory work is limited. Tobin (1990: 105) posits that:

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

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). The 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 through book knowledge alone: students engage in the knowledge production process through problem-solving activities that involve proven methods used in scientific learning environments that allow students to to identify and solve scientific problems themselves. The benefit of this hands-on engagement is that conceptual development is facilitated 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-centered approaches to teaching and learning which deprive students of skills and capacity to operate at a high level of expertise (Hamidu, Ibrahim and Mohammed, 2014).

3 THEORETICAL FRAMEWORK

This study was located within Bourdieu's theory of social capital (Bourdieu, 2005) and Maton's Legitimation Code Theory (Maton, 2014) Theory; established from Bashkir's theory on scientific capital (Bashkir,) and further revised in Maton's scientific realism theory (Maton; 2012). According to these theorists, scientific capital is the disciplinary knowledge that endows Life Sciences students with peculiar skills that are controlled by the environment. The diverse backgrounds of students include the social field and the social space that they occupy; contributing to the environment that has an impact on 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 capital and disciplinary knowledge. Life Sciences students, because of their diverse backgrounds, are differential agents of scientific capital in the disciplinary field. As agents they symbolically inform their acts of knowledge as well as asserting recognition of their abilities by peers (Bourdieu, 2005). The implication is then that this relation occurs in a graded manner because of their experiences. Students act within the constraints of the rules of a particular disciplinary field; in this case Life Sciences.

Using the theories of Bashkir (in Maton (2012) as a theoretical framework provides an in-depth study of abilities displayed by first-year Life Sciences students in executing required practical investigative tasks. (Bashkir, 1994a: 170). Maton (2012: 51), cites Bourdieu by stating that the social nature of knowledge accurately as encapsulated in the "habitus" which he defines "as a property of social agents (whether individuals, groups or institutions) that comprises "a structured and structuring structure". The above assertion explains that the term 'habitus' is "structured" by an individual's past and present circumstances: such as family upbringing and educational experiences. The relation between habitus or disposition of a Life Sciences student and the scientific capital of the Life Sciences discipline is tantamount to practice: denoting, in this case, knowledge practice; being able to manipulate apparatus and conduct practical work in the Life Sciences laboratory. The proponents of this theory suggest that it informs knowledge practices which are influenced by habitus (context where students are and where from which they are drawn) and hence knowledge acquisition cannot be divorced from prevailing circumstances and environment. Habitus relates to our way of being: the ontology which is actively and continuously evolving (Maton, 2012).

One way in which this study attempts to make sense of students' abilities to perform practical investigative tasks, and their knowledge practices in first year Life Sciences, is by using the principles of the Legitimation Code Theory (LCT) of Maton (2014). LCT is a sociological theory and a multi-dimensional toolkit that employs a bank of legitimation codes. One of the dimensions of the LCT is semantic waves which relates to social structure. The semantic structure or social field of knowledge practice determines its strength. Semantic codes therefore reveal knowledge practices. For the purpose of this study, the focus will fall upon semantic density which is one of the semantic codes that resort under semantic structure (Maton, 2014). Semantic density (SD) and semantic gravity (SG) both refer to the degree of condensation of meaning in making sense of the knowledge practices. Maton (2014) states that semantics range from more condensed meaning which is categorized as positive semantic density (SD+).I In this study such density refers to advantaged students exposed to laboratory environments at school level and the advantage of prior knowledge they bring with them to the university first year Life Sciences education laboratory environment. Less condensed semantic density refers to students who come to the laboratory having less experience in conducting practical work. SD- denotes their struggle to make meaning of concepts. This study aims at diagnosing where each of the first year students fits within this theoretical framework. This review of relevant literature highlights important concepts that form the basis for supporting data obtained from interviews and in situ observation collected from Life Sciences laboratory activities unpacking the impact of first year students' backgrounds enrolled in a Natural Sciences teacher education programme at a sampled Higher Education Institutions; to explore how different schooling backgrounds impact first year Life Sciences participation in practical activities conducted in Life Sciences laboratory.

4 METHODOLOGY

The design of this study is underpinned by the guidelines of an interpretive paradigm. Henning *et al* (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 this point of view by stating that the 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 subjects being researched in the context of the study. The implication raised within this paradigm in the empirical study undertaken was the interaction between the researcher and the participants about the social context (Henning 2004:20).

Qualitative methods of data collection were used through focused groups of two first-year pre-service teachers' interviews in six focused groups; consisting half of students from disadvantaged background and half from schools that had functional laboratories.

In-depth interviews were conducted in focus groups of five targeted participants per group. Semi-structured questions were prepared prior to the interview process. The rationale for choice of focused groups was that selected participants were categorized according to their background on exposure to practical work or laboratory environment. Field notes were taken by the researcher during the time when students were performing practical work in the Life Sciences laboratory.

Data collected through interviews were coded and analysed through the development of themes. Conclusions were drawn from data collected through both methods chosen in the study.

5 RESULTS AND DISCUSSION

Understanding different backgrounds of these students allowed the researchers to detect anxiety displayed by 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 common language; based on description of apparatus the way they see it. Students described a coverslip as a small glass; plain slide as its glass and a beaker as that thing we use for water.

In interviews a number of participants made utterances that revealed disparity 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 is 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".

This revealed that first year Life Sciences students have widely varying abilities in performing laboratory practical activities. Hoadley (2006) reveals how deep-rooted are the differential pedagogies in reproducing inequalities in social class differences of the South African schooling system. She explains that orientation to meaning is taken as crucial in including students in different domains of integrated disciplines of sciences and social science clusters. The review of relevant literature in the study highlights important concepts that form the basis for supporting data obtained from interviews and in situ observation collected from Life Sciences laboratory activities; unpacking the impact of first year students' backgrounds enrolled in a Natural Sciences teacher education programmes at a sampled Higher Education Institutions. This explorative study demonstrated how different schooling backgrounds impact upon first year Life Sciences students' participation in practical activities conducted in Life Sciences laboratory work.

The educational background in Life Sciences disciplinary knowledge affected how well students performed. Not all students knew how to handle instruments available in the laboratory. There were wide disparities between those who could and those who could not complete the microscopic task as well as the investigative activity conducted on the effect of membranes in potatoes and gummy bear sweets made from gelatine extracted from animal membranes; used to display the movement of sugar solution and ionised water. This experiment involved: (i) various stages of investigative inquiry into forming a hypothesis, (ii) proving the hypothesis students had before the investigative process was undertaken, (iii) the ability to take instructions, (iv) measurement skills especially when it came to weighing the mass in the intervals of 10 minutes as they needed to repeat all measurements five times including the initial measurement before the practical was conducted. It was observed with appreciation how some learners reported their findings through a research report. 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 (2005) social capital and Maton's Legitimation 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 negative semantic gravity to positive semantic gravity. Meaningful learning processes and group dynamics elevated scientific and social capital, which 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 invoke creativity, and inquiry there was a discernible increase in learning and performance with the demonstration of good to excellent performance in practical assessments.

Based on the way first year students improved, teacher educators involved in teaching these students, together with the researcher, noted that there has been an appreciable improvement in students' attitudes. The role of the researcher changed from that of being an 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 being "stupid" to take ownership of their learning process through a participative approach. It was consistently reinforced that every first year Life Science students had to start from somewhere. If they found challenges emanating from knowledge and skill gaps, help was not far away. But the purpose of doing practical work and linking practical to content knowledge skills allowed them to move from where they were not exposed to practical work and laboratory environment without any fear of the unknown and anxiety observed at the beginning of the study. The inquiry-based learning approach to learning and problem based learning was defined and unpacked in the literature review section above.

What was seen as varied students' backgrounds initially associated with social class slowly becomes to disappear; compared to the current state when students have now been exposed in five practical investigative types of work in the laboratory. The position of the researcher in the study as a laboratory technician gave him little or no space to contribute in the pedagogy suggested by the literature which would enable him to demonstrate how inquiry and problem based learning could be used as methods to aid in teaching students. The researcher could have explored laboratory practical teaching methodologies suggested in the literature reviewed for the study but he was limited to focus on the preparedness of all students for tertiary laboratory environment. The thrust of the researcher's argument has been on the abilities and skills or lack thereof displayed by first year students that proved laboratory preparedness. Orientation to meaning during the different practical tasks observed was based mainly based on the transmission and acquisition of more context independent meanings and more context dependent meanings.

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 have been exposed to different Life Sciences subject pedagogies requiring practical lessons as expected in the nature of the discipline: students from deprived backgrounds displayed adverse effects of exclusion or inclusion to ontological and epistemological aspects of their discipline. This double deprivation has been a pedagogical challenge that lecturers could not avoid.

6 CONCLUSIONS

It has been clear that even though we have gone beyond two decades of democracy, there still exist disparities in students' performance in the laboratory work. Exposure to more practical work and inclusive various pedagogies applied in the laboratory has been seen to improve when the social capital according to Bourdieu's social capital and Bashkir's scientific capital has been shown as being incremental. Students exposed to practical activities are exposed to inquiry and problem based learning which raises their performance.

There need to be innovations in the tertiary programme pedagogy regarding laboratory tasks which needs some sensitivity. Vast gaps do exist because of students' secondary school background and exposure to facilities. University lecturers need to engage in discourse on how these existing gaps in knowledge and practical skills can be corrected to set a platform for all students to progress to the next levels without lowering standards of knowledge of the Life Sciences discipline.

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