KNOWLEDGE GAPS IN FIRST YEAR LIFE SCIENCES LABORATORIES: "SCAFFOLDING" UNDER PREPARED STUDENTS THROUGH PEER INTERACTION

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Abstract - Globally, knowledge gaps in Life Sciences have been identified as causing low throughput - and high attrition rates in tertiary institutions. The purpose of this case study was to investigate how Life Sciences lecturers intervened by means of scaffolding to ameliorate knowledge gaps in the practical skills of first year Life Sciences pre-service teachers. Community of Practice theory was used as a lens to view how the scaffolding processes as well as group dynamics contributed to the dissemination of information among peers. All the first year pre-service teachers who enrolled for Natural Sciences were selected as subjects for this study. Three tasks were given to them - two tasks involved microscopy and one was a practical investigation on the rates of chemical reactions. The first task on how microscopes are operated was not assessed but was designed to allow students to practice and teach one another on how the apparatus is adequately used, in order to orientated those who never had an opportunity to physically touch and manipulate microscope for viewing purposes to have a firsthand information and to be upskilled by those who were competent in using them. The researchers used a strategy based on community of practice by grouping students with capable practical skills with those who came from disadvantaged schooling backgrounds. Based on the assumption that students enrolling for first year Natural Sciences at the university have all passed matric Life Sciences with 50% or more, it has been evident that different students within the same cohort have different experiences due to their different schooling backgrounds. This study confirmed that there are indeed gaps in appropriate skills to perform practical tasks. It was concluded that using peer learning activities in a scaffolding manner is a possible strategy to assist in erasing such gaps.

Key words: Life Sciences, peer learning, community of practice, practical work, knowledge gaps.

Introduction

Developing countries have been associated with disparities in social classes caused by political ideologies adopted by the governmental structural changes. These ideologies often have an impact on the stratification of societies into classes associated with their socio-economic status (Fisher and Scott, 2011; Bokana and Tewari, 2014). Among the areas associated with social classes is the influence of these ideologies in designing, implementing and evaluating both school and Higher Education Institutions (HEIs) curricula. South Africa has not been immune to these classifications of citizens according to their social standing. These social classes have affected or contributed to the different schooling backgrounds associated with the classification of schools within different societal groupings. The South African education system itself before the democratic era has been fragmented according to race and social standing of the citizens (CHE, 2013; Fisher and Scott, 2011; Booyse; le Roux, Seroto and Wolhuter, 2011). The democratic dispensation has then introduced the notion of equal education for all citizens of the country aiming at redressing the imbalances that were created by the previous regimes (DoH, 1998).

Democratisation of education in South Africa resulted in the transformation of education systems (paradigm shifts) 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 the education curriculum (Meyer and Land, 2003). While the system of education changed there was an issue of correcting anomalies created by the previous dispensation which involved the redress of disparities in schools created by the previous regime. In the same vein, the issue of the status and condition of schools has not been urgently addressed. This notion has resulted in the children of those who possess wealth as well as the working class who manage to provide their children with better education sending them to ex-model C schools which are 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 the learners' performance in scientific disciplines (Meyer and Land, 2003; Booyse; le Roux, Seroto and Wolhuter, 2011).

At the other end of the scale, there are citizens who have had to settle with under-resourced schools and in some instances under-qualified teachers who struggle to impart disciplinary knowledge in Life Sciences classrooms due to the absence of Life Sciences laboratories as well as under resourced laboratories in some cases (Botha and Reddy, 2011, Meyer and Land, 2003; Booyse; le Roux, Seroto and Wolhuter, 2011). Consequently, the outcome of these segments in education resulted in diverse students enrolling for Life Sciences education in teacher training and development at the universities.

First year pre-service teachers in Life Sciences have shown signs of disparity in the classroom and in the laboratory activities. This situation has caused anxiety in those students who were just introduced to working in laboratories carrying out scientific experiments as required by the discipline. On the other hand there are students who are endowed with the required skills to manipulate equipment and who find it easy to carry out investigative tasks required in the first year Life Sciences disciplines due to the advantage they gained from their high school education (Botha and Reddy, 2011). The difference in schooling environments has been seen as the exclusion or inclusion factor in the investigative exercises performed in the Life Sciences' laboratories. 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 and Reddy, 2011).

The issues presented above continue to contribute to widening the knowledge gaps in Life Sciences education disciplines. The problem this study seeks to address is to find a way of scaffolding students who have been deprived of embarking in investigative practical activities in Life Sciences laboratories at the first year university level through involving others who are better equipped with skills necessary to carry out investigative work in the Life Sciences laboratory. Life Sciences lecturers undertaking this study purposefully engaged the concept of "each one teach one" through mixing the students who are adequately prepared with the under prepared students. The purpose of this exercise is to provide all the students with those abilities that will provide them with epistemological access to Life Sciences disciplinary knowledge in the university teacher education programs - in particular performing investigative practical work in the laboratory. It is therefore important that Life Sciences lecturers continue to attempt to narrow the knowledge gaps in their classrooms (Kuiper, 1994).

Research questions

- How can the knowledge gaps in Life Sciences investigative practical work be reduced to ameliorate the impact of lack of prior knowledge in practical work at the university teacher training and education programme?
- Why is the interactive scaffolding approach chosen for this study seemed to be suitable in closing up knowledge gaps in investigative practical activities performed in the first year Life Science laboratory work?

Literature Review

It has been documented internationally that undergraduate students encounter academic challenges especially during their first years at university. South Africa is not immune to this situation. The disparities in education systems has created huge gaps between the schooling infrastructure resulting in an unequal distribution of resources that has been perpetuated by the privileged students coming from the low income status in the society and those who went to well-resourced schools because of the affordability or income brackets per capita in the society (Jansen and Christie, 1998; Jansen, 2002). Due to the legacy of the past education system, most schools who struggled with resources to teach and learn Life Sciences are still battling with resources (Booyse; le Roux, Seroto and Wolhuter, 2011). This notion is compounded by the fact that students enrolling at universities, coming from the disadvantaged backgrounds and having been taught by under-prepared Life Sciences educators, put a mammoth task on the teacher educators to address disparities in their Life Sciences classrooms at the universities.

Lecturers therefore have to firstly access the first year pre-service teachers' prior knowledge of Life Sciences before they can plan their work according to the content level that is consistent with HEQF level 5 competencies (DHET, 2011). This often puts an additional load on teacher educators as they cannot proceed with students who are academically underprepared when joining the programme. It is difficult to ignore the reality of disparities in the schooling system which continues to plague the South African education system and under-preparedness of students who join the Life Sciences teacher education program at the university. If these knowledge gaps are left unattended, they could contribute to the high failure rates as well as high attrition rates and consequently to the low throughput rates in the Life Sciences teacher education programmes. This study aimed to diagnose the impact of Life Sciences content knowledge gaps on the practical skills of first year students at the university where this investigation is conducted and to provide measures to ease the challenge. From the synthesis of literature on social justice, recommendations were provided on how the researchers dealt with these knowledge gaps that are linked with different levels of prior knowledge first year Life Sciences pre-service teachers bring to the university classrooms.

The National Framework for Teacher Education in South Africa (1995, pg. 13) states that newly qualified teachers are frequently criticised for being under-prepared in the content knowledge they teach. It is further speculated that some interpretations of Outcomes Based Education (OBE) and valorisation of 'learner-centred education' have contributed to the under-emphasis on content knowledge and the ability to make it accessible to learners. DoE (1995) argues that initial teacher education materials tend to over-emphasise theoretical strategies rather than practical strategic actions that novice teachers require.

There is a growing demand that universities or teacher training institutions produce empowered graduates of education that will operate along the principles of the curriculum of their dispensation as well as being provided with the space to critically engage in the ongoing dialogue of curriculum reforms. This notion is perpetuated by the fact that the curriculum changes as the context or the political agenda changes at schools. The policy guidelines of Minimum Requirements for Teacher Education and Training (MRTEQ) highlights exactly where we might be falling short based on the continuous revisions of curriculum at schools. The attributes of the graduate in teacher education programmes need to embody the seven attributes of the envisaged teachers who are endowed with depth in content knowledge of their chosen discipline as spelled out in the National Curriculum Statement policy on teacher development and training as well as in the espoused curriculum of MRTEQ (DHET, 2015). The DHET charged the universities for producing incompetent teachers who are wanting in depth in content knowledge and hence gazetted a policy (MRTEQ) to ensure that teachers produced by universities demonstrate depth in content knowledge in their subjects as well as pedagogical content knowledge.

Theoretical framework

The principles of the philosophy of community of practice seems to best explain the use of scaffolding as an approach to bridge knowledge gaps in the practical skills of first year Life Sciences pre-service teachers. Wenger and Trayner (2015) define communities of practice as groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly. Community of practice can also be viewed as " part of a broader conceptual framework for thinking about learning in the social dimensions that locates learning in the relationship between the person and the world where the social and the individual constitutes each other" (Wenger, 1: 2012). The emphasis is thus on learning that occurs through social interaction that is contained not only within the classroom or laboratory but the application of acquired knowledge extends to the broader learning system of the outside world . When students actively apply what they have learnt by interacting with their peers then they form a community of practice (Kapucu, 2012).

The required components of any community of practice are the following three: firstly a common domain of interest or knowledge that define its identity, secondly a community consisting of the committed members of that domain who share, interact and engage with each other while building relationships and thirdly a practice that allows for the intuitive development of a shared repertoire of resources over time and therefore making the members of the community of practice its practitioners (Wenger and Trayner, 2014).

If learning takes place through social participation then according to Wenger (2012) learning is central to human identity. Individuals continuously construct their shared identities as active members who participate and engage with societal - or social community practices. In doing so the more central a participant becomes in a community of practice, the stronger the motivation is to learn. The knock-on effect is that other individuals will desire to develop skills similar to those of the one they admire.

For the purpose of this study then the first year Life Sciences pre-service teachers who are scaffolded by peer interaction to bridge knowledge gaps in their practical skills fulfill the requirements of a community of practice. Over time researchers had proven community of practice as set out by Lave and Wenger (1991) to be an effective, dynamic and productive learning practice that serves as a vehicle for peer-to-peer learning in an enabling environment by means of appropriate use of resources. The more skillful Life Sciences students use their experience, knowledge and skills set to assist by means of scaffolding those who lack skills and present gaps in their background knowledge when it comes to practical work in the Life Sciences laboratory.

Methodology

The sample was drawn purposively to identify the two categories of students in the first year Life Sciences sub discipline of Natural Sciences first year course: those who had a prior exposure to laboratory work and those who came from backgrounds where they could not access practical were work due to various reasons which are stated in the introduction of the study. The whole first year Life Sciences class was therefore selected for this case study (Babbie and Mouton, 2007). Out of the population of first year Life Sciences pre-service teachers, groups of five were purposefully sampled where 2 of the group members had exposure to laboratory work including microscopy was paired with 3 students who never handled a microscope or did practical work in the laboratory at school. They were orientated during the lecture as to how and why a microscope is used. Papers with a lower case e was given to them to mount on the stage of a microscope and a demonstration was done to show them how low to high magnification in microscopes are used. It was in that exercise that students who had never used a microscope were identified. The rationale behind the choice of this sampling strategy was to monitor the progress of each group. Students who had the knowledge and skills of using a microscope were trained on how they could assist those who displayed lack of the required knowledge and skills. Following the orientation task, students were given onions from which they had to remove the epidermal layer and prepare a wet mount to study under low and high magnification of the microscope. This task was followed by the preparation of wet mounts of cheek cells and similarly studying them under low and high magnification

In the final task of investigating the rates of chemical reaction (appendix 2), students were again allocated to the same groups of 5 anyhow as long as they were not in the same groups for the previous tasks on microscopy. Each group was provided with the necessary apparatus and was instructed to follow the procedure outlined on the work sheet provided to them.

The researchers recorded their observations in a structured manner at the site of the study (Bertram and Christiansen, 2014). These observations, based on the groups' interactions, the groups' performance as well as the focus group discussions or debriefing sessions held at the end of each practical task performed were analysed qualitatively so as to make meaning of the individuals' experience (Cohen, Manion and Morrison, 2000). Score that each individual obtained in task 1 and task 2 are presented in the form of bar graphs in the results section. The purpose of these discussions was to trace if the research strategy has had a positive or a negative impact on the practical skills of the disadvantaged students from the first to the third investigation.

Results and discussion

Table 1: Scores obtained from Practical 1 (on plant and animal cell microscopic practical and Scores obtained on Practical 2 (which dealt with the rates of combustion of Peanut (Protein) and raisin (Carbohydrate).

Respendents	Pract 1	Pract 2
S_NO	100	100
216178630	80	73
215263693	84	73
216080878	84	60
215214986	80	60
216152496	68	73
216127874	76	53
214107701	64	87
215072804	80	73
216035600	64	73
213117746	84	73
216029058	88	87
215045041	96	73
215186907	100	73
216156270	100	87
215037421	88	53
215280598	64	73
216026687	88	87
215247582	0	73
215050983	80	73
216027381	92	87
216193257	80	73
215104498	84	73
215232607	80	60
216108160	72	67
216111145	88	53
215143779	0	53
216176093	80	60
214208206	84	60
216015383	80	53
215065425	76	73
216094844	88	73
215048601	64	60
214012581	60	60
213341190	88	73
216182409	96	60
216018102	60	53
215146735	84	60
216117933	80	60
216205719	68	87
216070104	88	73
216113857	84	60
216287049	80	67

216230276	88	67
215285794	84	0
214372030	76	60
215228901	56	73
215269950	72	0
215081102	68	67
216081718	80	73
216138655	64	73
216181313	60	73
207134596	68	73
208112413	72	73
216066158	64	73
215084748	76	73
215034473	68	0
210151218	92	60
215003012	76	73
215293665	80	80
216123682	76	73
214127230	76	67
216085918	64	73
216025540	88	67
214215709	68	73
215135261	60	67
216028647	84	80
216093775	72	67
216032482	84	80
216066794	76	60
215107926	80	67
215197666	60	80
214244172	80	60
214235866	68	60
216090989	80	73
216109256	80	80
216091500	64	0
216058635	84	0
216190851	80	80
216112729	80	0
215313941	80	67
216170176	84	67
209078898	88	73
216019168	96	73
215238451	72	80
216027551	76	67
214140857	80	67
216252288	88	73
212142801	68	80
216169917	80	80

215093542	80	80
214149250	68	80
216164001	76	73
216039053	0	60
215148290	76	73
216191041	84	80
216002125	76	73
216124840	72	73
211080950	76	0
215053877	80	0
216207835	68	60

Students who had sufficient prior knowledge and who were identified to have the necessary practical skills during the first practical task continued to explain concepts and how to follow protocols for each task they had to execute. On observing the group dynamics it was very heart-warming to observe competent students willing and dedicated in assisting others as well as how patient they were with their peers whom they were assisting. Results on worksheets scores demonstrated that there was indeed learning opportunities created as the community of practice was created among students to learn from interacting with each other. On debriefing after they had completed the task, both sets of students in each group were very positive about what they both derived from the exercise. Assessment of the practical task also demonstrated that there was indeed a benefit in peer interaction as a teaching and learning strategy. On debriefing after the practical was completed some students reported that they were handling microscope for the first time, with a few who reported that their schools had such resources but never got to use them. My speculation on the latter was that teachers at the schools where the latter group comes from were challenged in one way or the other when it came to demonstrating the use of the microscope. Researchers were aware of the fact that some schools lack resources to effectively teach Life Sciences due to reasons like overcrowded classes, lack of laboratories and under-preparedness of educators to handle such equipment as well due to huge workloads. At the other end of the scale, the better equipped students seemed to have been taught by skilled Life Sciences teachers in better resourced schools.

The highlight of this intervention was that students became confident and were able to inform one another of the challenges that they were facing. In as much as community of practice has been selected as a lens to view the data, social constructivism became prominent as all students were involved in activities while they were assisting one another. The role of the lecturer alternated between that of a facilitator and a mediator whenever there was a need to do so. The first year pre-service teachers were given a space and opportunity to apply what they have learnt in the worksheet provided towards the time allocated for the task. The performance of students in these tasks demonstrated that students managed to grasp the concepts and skills needed for the task.

Again, in the subsequent practical task of investigating the rates of chemical reactions, all students were confident in observing the protocol of the investigation. When comparing the combustion of a peanut to that of a raisin, generally they were able to predict which one of the two would cause an increase in the temperature of the water in the can. These predictions that were fortified by their observations as well as interactions with their peers allowed them to make links between the task performed and scientific concepts. An example of this would be that the raisin containing sugar and the peanut containing lipids and proteins have different rates at which energy is released and subsequently connect all the information acquired with the role of enzymes in the hydrolysis of food types in the digestive system (Raven, 2014).

Conclusions and Recommendations

It became evident that gaps do exist in Life Sciences classrooms in as far as practical work is concerned. Due to the nature of the subject, practical work forms a critical part in the comprehension of the content and the building of a knowledge base of this science discipline. For this reason, interventions have to be done at different levels to empower schools which lack those resources which are accessible to the majority of schools. It has also been noted that there is a need to up-skill educators who lack competencies to teach the subject since it has been clear that there is a serious scarcity of skilled and competent Life Sciences teachers. While there needs to be strategies that can be used as early as possible to try and identify the challenges caused by such gaps in conceptualising and executing practical work, such interventions as previously mentioned should be considered before it is late to intervene. The early detection of students at risk could result in lecturers identifying ways and methods of intervention that would serve as scaffolding mechanisms for these students without ignoring those who display capabilities to perform well in practical work. This would not just assist lecturers to diagnose the capabilities of their students but would also in time flag those students who are academically challenged.

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