THE IMPORTANCE OF PRACTICAL WORK IN THE TEACHING AND LEARNING OF INTEGRATED NATURAL SCIENCES AND HEALTH EDUCATION AT THE UNIVERSITY OF NAMIBIA, RUNDU CAMPUS.

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ABSTRACT

This research paper reports on the importance of practical work in the teaching and learning of integrated natural sciences and health education (INSHE) at Rundu campus. This research was triggered by Ministry of Education report of 2004 which raised growing concerns about the amount and quality of practical work carried out in secondary schools that have both suffered as a result of the impact of the national and international tests in science worldwide. This emanated from a high percentage of secondary school science teachers who experienced a fall on time spent on practical work that appeared to be between one third and a half of all lesson durations. The aim of this study was to enhance the understanding of theory by using practical work. The study adopted a mixed approach method in reporting informants' views as data was collected from several laboratory

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experiments where it was found out that the informants lacked rudimentary knowledge, methods and skills. It is against this backdrop that this research used questionnaires and semi – structured (stimulated – recall) interviews for the purpose of providing allogamy of claims and ideas. This study involved a total of ninety – three (93) pre -service INSHE student – teachers. These informants were purposefully selected due to lack of exposure in practical work from their former schools. The findings from this study indicated that there is both a degree of exposure and enhancement of conceptual understanding of theory using practical work after student-teachers have been exposed to practical work at the University of Namibia, Rundu Campus (UNAM:RC). The results also revealed that there is a need for improvement in administering practical work in schools. It is evident that practical work plays a very important role in the teaching and learning of integrated natural sciences subjects.

KEY WORDS: practical work, hands – on, brains – on, content knowledge, informants (students-teachers).

INTRODUCTION

The UNAM: RC is situated in the Kavango East region. The campus now has a fully-fledged university status, after the merger between the former colleges of education and the University of Namibia (UNAM) in 2011. The campus offers accredited programmes at two of its faculties, namely, the Faculty of Economics and Management Sciences (FEMS) and Faculty of Education (FoE). The latter comprises eight departments; the Department of Mathematics, Science and Sport Education (DMSSE) is one of the departments envisaged with the responsibility of training teachers for Mathematics, Integrated Natural Sciences and Health Education, Home Ecology, Agriculture and Sport

Education at upper primary phases. The informants resort in the DMSSE majoring in Mathematics and Integrated Natural Sciences and Health Education, the ultimate, being the main focus of the study. The study was propelled by a plethora of observations based on handling and using laboratory apparatus and other equipment such as microscopes, biurettes, measuring cylinders, Van der Graaf generators, ammeters, voltmeters, triple beam balances to mention but a few. It also unfolded that the informants lacked scientific skills such as measuring, classifying, predicting, and experimenting along with scientific knowledge based on the methods and procedures. This is in harmony with the findings of (Science Community Representing Education [SCORE], 2008; Lunetta, Hofstein & Clough, 2007; Millar, 2004; Hofstein & Lunetta, 1982) who found out that “hands – on” learning experience prompts thinking about the world in which we live. Good quality practical work promotes the engagement and interest of students as well as developing a range of skills, science knowledge and conceptual understanding. In congruency, the research by Joan (2018) in South Africa found that with clear objectivities and step-by-step, students nurture confidence, gain understanding, acquire skills and develop critical thinking that enable them to work confidently and independently as scientists in their classrooms (Cambridge University Press, 2018, p.2). Therefore, science begins when students realise they learn about the world and construct their own interpretations of events through their actions and experience. This is not simply about hearing or reading about it, but engages and allows students to test their own ideas and build their own understanding (Ewers, 2001).

THEORETICAL FRAMEWORK

The framework of this research focused on problem-based (or principle-based) learning (PBL) that refers to a teaching and learning method rooted in medical sciences, first introduced in Hamilton, Ontario, at McMaster University Medical Programme, 1969 (Coombs & Elden,

2004). Within a few years of the commencement of the PBL concept, it was taken up promptly and infused in the educational curricula of Australia, Israel, the Netherlands and the United States. This method of teaching and learning also became popular in other academic disciplines such as psychology, nursing, education and business. The principle-based teaching and PBL in nursing as related to clinical skills taught according to principles whereby students learn key principles associated with the skills, and then apply those principles to the actual performance of the skills (Hally, 2009, p.6). However, in education, this method became increasingly popular in science subjects such as Biology, Chemistry and Physics which aim at the development of skills (General and Technical), knowledge and understanding of integrated natural sciences concepts. Therefore, from a social constructivist perspective, science teachers should place learners at the center of teaching and learning endeavours which create a good learning environment for learners to construct their own knowledge instead of just absorbing it (Ministry of Basic Education, Sport & Culture, [MBESC], 2004). In this case, learning is driven by challenging, open-ended problems and facilitated by the teachers and learners working in small groups. It is the role of the teachers to scaffold by providing sufficient assistance to the learners and then gradually reduce the assistance as the learners learn to work independently.

LITERATURE REVIEW

“Practical work is part and parcel of what teaching and learning in science is all about” (Woodley, 2009. p. 49)

Practical work is defined as learning experiences in which students interact with materials or with secondary resources of data to observe and understand the natural world (SCORE, 2008, Millar, 2004; Lunetta, 2007 et al., Woodley, 2009). In addition, it is defined as “hands – on” learning experience which prompts thinking about the world in which

we live. The definition entails that good quality practical work promotes the engagement and interest of students as well as developing a range of skills, science knowledge and conceptual understanding. Furthermore, (Ateş & Eryilmaz, 2011, p.3) avowed that several literatures have shown that hands-on activities help students to outperform students who follow traditional, text-based programmes (Bredderman, 1985; Freedman, 1997; Glasson, 1989; Shymansky, 1989; Staber & Small, 1990; Stohr-Hunt, 1996, Turpin, 2000), to enhance their understanding and replace their misconceptions with the scientific ones (Coştu, Ünal & Ayas, 2007; Ünal, 2008), to develop attitudes towards science positively (Bilgin, 2006; Bredderman, 1983; Bristow, 2000; Janus, 1977; Kyle, Bonnstetter, & Gadsten, 1988; Schibeci & Riley, 1986), and to encourage their creativity in problem solving, promote students independence, improve skills such as specific reading, arithmetic computation and communication (Haury & Rillero, 1994; Straver & Small, 1990).

These assertions of promoting students to be independent critical thinkers, investigators, problem- solvers and interpreters of data by applying learnt knowledge from experiments and investigations applied to students daily lives are precise and cemented in the national curriculum guidelines that are incorporated in the Namibia Senior Secondary Certificate Ordinary Level (NSSCO) syllabi for Physical Science (Ministry of Education, 2009, p.2). The relevant skills that are encompassed in the NSSCO are communication, numeracy, information, problem-solving, self-management and competitive; social and cooperative; physical, work and study, as well as critical and creative thinking. These were necessitated by the failure of Namibian teachers' reluctance to adhere to the implementation of the philosophy of learner-centered in their teaching country wide that affected the exit-learning outcomes which resulted in poor performance in science (MBESC, 2004). Research by (Ylanne, Trigwell, Nevgi & Shiwin, 2006) found that teachers who teaches in "hard" discipline, such as physical science, engineering and medicine, are likely to employ a teacher-

centered approach to teaching, whereas learner-centered approach are commonly used in “soft” disciplines such as social sciences and humanities. The dominance of teacher-centered lessons and under use of experimentation had compelled researchers and educators to pursue a variety of options to address such challenges. Researchers such as (Qhobela & Moru, 2011; Boyle & While, 2004) found that approaches such as study groups, whereby students collaborate and interact in small groups around a topic assigned to them are more likely to make a positive impact on their practice than traditional approaches such as question and answer used in teacher-centered approach. Equally, the findings of (Mutilifa & Kapenda, 2017) showed that usage of various learner-centered approaches improves high school learners’ conceptual understanding in physical science (p.1260).

Moreover, since practical work in science is defined and considered to be a hands-on and brains- on (minds-on), such activities according to (Woodley, 2009; Practical work in, n.d) should be associated and categorised as follows:

- **core activities** – investigations, laboratory procedures and techniques, field work procedures and techniques. These hands-on activities support and shape students’ practical skills and scientific concepts in sciences.
- **directly related activities** – designing and planning investigations, data analysis using ICT, analyzing results, teacher demonstrations and experiencing phenomena. These provide valuable first-hand experiences to students in learning and understanding science concepts.
- **complementary activities** – science related visits, surveys and presentations and role plays, models and modelling, group discussions, group text – based activities and simulations.

Consequently, the purpose and importance of doing practical work is to encourage accurate observations and descriptions; to make phenomena more real for example lightning; to arouse and maintain

interest, to promote logical and reasoning methods of thought; develop a critical attitude, develop ability to cooperate; practice seeing problems and seeking ways to solve them, lastly for finding facts and arriving at new principles (SCORE 2008; Ministry of Education, 2009). Research by Hally (2009) in Australia found out that in self-directed learning, students take responsibility for their learning and organise their own study (p.7). There is evidence that if practical work is well planned and effectively implemented, students will be mentally and physically engaged. Secondly, it can also increase students' sense of learning ownership and motivation. This only happens if teachers' good practice and effective pedagogy are fully integrated as major elements in science. The notion is supported by Shadreck & Isaac (2012) who stated that teachers' competence in the classroom, teaching skills, abilities to explain scientific concepts clearly as well as their willingness to address and answer learners' difficult questions promotes learners' acquisition of knowledge and skills when various teaching methods, such as group work, problem-based learning and practical work are applied effectively. The same notion was also supported by (Killen, 2013; Skinner, 2010) who found out that teaching and learning expectations are achieved successfully in the classroom when learners take full responsibility for their learning.

Arguably, although evident from research by the Ministry of Education (2009) shows that practical work is one of the methods used in teaching and learning of biology, chemistry and physics and it is a prominent feature in all science subjects' curricula in the Namibian schools (p.5). However, there are challenges that hinder the successful implementation of practical work. This is evident in the recent research by Daniel in East Africa (as cited in Cambridge University Press, 2018) which showed that there has been a vigorous and widely reported discussion over the educational consequences of class size difference; teachers' inexperience; facilities; planning and preparation time; resources and technical support (p.2). This concurred with the findings by Kapenda, Kandjeo-Marenga & Kasanda (2002) who found that to

deal with large classes and lack of equipment Namibian science teachers use the practice of “sequence group demonstrations” (p. 60). In addition, Kandjeio – Marenga (2011) pointed out that most Namibian science teachers find it difficult to teach science practical work due to the lack of well-maintained modern laboratories and other resources. This situation forces teachers to resort to teacher demonstration methods rather than group experiments in teaching science practical work. In the United States of America (USA) the discussion was centered on efficacy and cost effectiveness of class size reduction, while in the United Kingdom (UK) it was more about the negative effects of large classes (Blatchford, Russell, Bassett, Brown & Martin, 2006). However, more of the research and discussions on class size have been about relationships between class size and academic outcomes and has little to say about classroom processes that might explain the effect (Anderson, 2000; Finn & Achilles, 1999; Grissmer, 1999 as cited in Blatchford et al., 2006). New evidence has shown that students are not experiencing complete and authentic education in the sciences due to lack of resources for practical work (Practical work in, n.d).

METHODOLOGY

Research design

This study adopted a mixed-method approach in reporting informants' views. In the quantitative method, data was collected using questionnaires while semi – structured (stimulated – recall) interviews were used on the focus group discussion (FGD) in the qualitative design for the purpose of providing a degree of cross checking claims and ideas.

Population

The population consisted of ninety-three (93) INSHE student-teachers from UNAM: RC of which forty-one (41) were second (2^{nd}) years while twenty-six (26) were third (3^{rd}) years as well as 26 fourth (4^{th}) years.

Sample

A sample of approximately thirty (30) students-teachers was drawn from the population using a stratified random sampling method. This sampling method was used to select the informants based on lack of exposure in practical work from their former schools.

Research instruments

As alluded to in this research paper questionnaires and interview focus group discussions were used to collect data. Questionnaires were given to selected student – teachers and responses that emerged from the questionnaires lead to the stimulated – recall focus group discussion. Additionally, documents such as school syllabi, UNAM integrated natural science and health education (years 1-4) course outlines, UNAM FoE, and General information and Regulation prospectuses (2015-2016) were perused and analysed.

RESULTS AND DISCUSSION

The results and discussions focused on the importance of practical work, barriers and challenges that impede the execution of practical work in schools in comparison with the significance of carrying out practical work at the UNAM: RC. The findings that emanated from experiments, questionnaires and focus group discussions are as follows:

Experiments

The researchers observed that informants were not able to identify, handle and use laboratory apparatus and equipment such as microscopes, biurettes, measuring cylinders, Van der Graaf generators, ammeters, voltmeters, triple beam balances to mention but a few. It also emerged that the informants lacked scientific skills such as measuring, classifying, predicting, and experimenting along with scientific knowledge based on the methods and procedures. This concurs with the findings of Haury & Rillero (1994) who avowed that hands-on activities involve students manipulating objects to acquire knowledge, skills and conceptual understanding. In support of Haury & Rillero, Hake (1998) asserted that students using interactive engagement or active learning methods retain knowledge of science concepts better than in traditional lectures.

Questionnaires

It surfaced that the informants indicated the importance of practical work and the challenges encountered in their former schools:

- Curriculum content & Teachers inexperience.

The Natural Science and Health Education curriculum in schools offers multiple disciplines that address the demands of the modern science and technology. This curriculum is also built around students' problem

solving exercises while mastering interdisciplinary concepts which are intertwined in Biology, Chemistry, Physics, Mathematics and Statistics to achieve a dynamic understanding of a wide range of elementary principles within the modern scientific methods. The findings revealed that $\frac{90}{93}$ (96.8%) of the informants indicated that teachers and learners lack knowledge and skills in understanding and seeing that different disciplines are intertwined when carrying out practical work. Therefore, in order to improve learners' achievements in science-related subjects researchers such as (Saville, Zinn, Neef, Norman, & Ferreri, 2006; Sikoyo, 2010; Auwal, 2013) found out that different teaching approaches such as problem-solving, demonstration and discussions promote learners' active engagement in the learning process and test students' retention of a specific science subject knowledge.

- Resources and Facilities

This study also stipulated that most science teachers do not feel equipped enough to provide their learners with the full learning experience due to lack of equipment and lack of access to appropriate facilities such as laboratories. This was specified by $\frac{92}{93}$ (98.9%) of the informants. However, some schools do not have laboratories but some have fully equipped laboratories which are not being effectively utilised as they are just "White elephants". In addition, inadequate resourcing for practical work is a long-term problem that should be a shared responsibility between the Government (Ministry of Education) and the schools as this is not just a simple matter of lack of government funding. Schools must share part of this responsibility by allocating at least 15% of their budget from the school development fund or from outsourced funds for this important aspect of science learning. In this way learners will be directly and actively involved in practical work at secondary level which will make it easier to comprehend the advanced science at UNAM and different industries.

- Class size

It emerged from the literature in the study by (Daniel in East Africa 2018, Kandjeio-Marenga 2011, Blatchford, et al., 2006 & Kapenda, et al., 2002) that there is more individual attention, more active roles for learners and beneficial effects on the quality of practical work in smaller classes than in larger classes. It is therefore important for science teachers with large groups of more than 30 learners as per teacher-learner ratio, the average number of learners per teacher in secondary school in Namibia to develop strategies, be creative and improvise when carrying out practical work. Additionally, the Namibian science teachers should identify and recognise the benefits of other forms of learning such as cooperative learning which entails positive interdependence, individual and group accountability, interpersonal and small group skills, face-to-face promotional interaction and group processing. Therefore, this teaching strategy whereby small teams, each with students of different levels of abilities, use a variety of learning activities to improve their understanding of a subject. All the informants unanimously and categorically stated that they were more than 40 learners per class in their former schools. As a result of these large classes, Namibian science teachers tend to demonstrate practical activities and learners are not directly involved and this contributes to lack of interest towards practical sessions and resentment of the subject resulting in poor performance in tests, projects and examinations.

- Lesson length (Duration)

It emerged from the document analysis that time allocated for practical work in schools is 80 minutes and at UNAM: RC 120 minutes, which are sufficient for practical sessions. The findings in the study pointed out that the duration for the practical is not optimally used due to some the following factors: lack of resources and equipment, technical support, skills, improvisation and in some cases unpreparedness. The informants in this study revealed that they have gained knowledge and

skills on how to prepare and carry out practical activities in integrated natural sciences and health education at UNAM: RC.

- Examination and Assessment

Assessment in science is a critical step in the learning process as it determines whether or not the course's learning outcomes have been achieved. Research by Ministry of Education (2004) has revealed that assessment affects many facets of education such as student's grades, placement, advancement as well as curriculum instructional needs and school funding. The teaching of natural sciences provides many opportunities for learners to use the immediate environment in their everyday situations to investigate phenomena using a scientific approach. In a knowledge based society, existing knowledge should be constantly evaluated for new knowledge and skills to be acquired. The findings from the informants revealed that teachers only focus on assessing theory neglecting the practical component due to lack of practical based examination especially at ordinary and extended levels. It is against this backdrop that most learners tend not to answer practical based questions correctly due to lack of exposure to practical work. This creates challenges when they join the University because they are not well versed in practical work as they lack experience and practice.

- Technical support

It emerged from the informants that most schools do not have laboratory technicians. Laboratory technicians help in setting up experiments, ordering of equipment and chemicals and managing the laboratories. Due the unavailability of laboratory technicians, who were supposed to order and setup practical activities, it emerged in the study that some schools lack common equipment such as beakers, test-tubes, microscopes, eye protection, electricity circuit boards, electroscopes just to mention a few.

- Impact of practical work

When the practical work is well planned and effectively implemented, students are both mentally and physically engaged. This concurs with (Shadreck & Isaac, 2012; Lunetta, Hofstein & Clough, 2007) who stated that students must manipulate ideas as well as materials in the school laboratories. It also emerged that effectiveness of “hands - on” and “brains - on” activities inside and outside the laboratory increases student’s sense of ownership of their learning and can also increase their motivation. This enables students to build a bridge between what they can see and handle (hands – on) and scientific ideas that account for their observations (brains-on), in other words practical work supports skills development, independent learning, experimental learning, learning in different ways and the development of personal, learning and thinking skills and how science works.

CONCLUSION AND RECOMMENDATIONS

In conclusion, practical work demonstrates the wonders of science so much more effectively than words on a page or pictures in a textbook. Therefore, to inspire the next generation of scientists in Namibia, educators need to ensure that all learners in schools are exposed to the exciting and increasing understanding of science that carrying out experiments can enhance the learning in the science arena. We therefore recommend that:

- Curriculum developers should make sure that practical work is assessed in both core and extended levels not only at Higher International General Certificate of Secondary Education (HIGCSE) level.
- The University of Namibia should embark upon a national training course on developing practical work guides and this training should be facilitated by UNAM: Rundu Campus. This will enhance the understanding of the importance of practical work in the entire Namibian education fraternity. Furthermore, the study recommends that an intervention programme needs to be set up after the training course in order to trace if what was learnt is being implemented by the science teachers that were trained in the national training course. In addition, the school management should monitor the weekly practical activities and make sure that they are being carried out and assessed as per curricula regulations.

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