SCIENCE TEACHING ORIENTATIONS FOR CAPS PHYSICAL SCIENCES PRACTICAL WORK: A CASE STUDY

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ABSTRACT– The inclusion of prescribed practical work activities for assessment compels teachers to work through contextual factors that inhibit the integration of practical work to ensure successful implementation. This study explored how eight physical sciences teachers from different school contexts implemented the prescribed and recommended practical work activities using the nine science teaching orientations by Magnusson as conceptual framework. Using a qualitative case study approach, purposive sampling was used to select eight teachers from different school contextual settings drawn from the Gauteng and North West provinces of South Africa. Data were collected by means of semi-structured interviews, lesson observations and worksheet analysis which were analysed through recursive and constant comparison techniques. The findings of the study indicated that the teachers displayed a core teaching orientation comprising process skills, academic rigour and conceptual change, didactic and activity-driven characteristics. The teachers understood that the purpose of the practical work activities was for verification and assessment and therefore were less inclined to display science teaching orientations for discovery, project-based, guided inquiry and inquiry. The study recommends that teachers be supported in order for them to expand their science teaching orientations for practical work to include discovery and the inquiry forms.

Keywords: CAPS; Physical Sciences; Practical work; Science teaching orientations.

1. INTRODUCTION

Discussions about teaching orientations date back to 1980s and the 1990s (Fox, 1983; Sanders & McCutcheon, 1986; Grossman (1990), Samuelowicz & Bain, 1992; Magnusson, Krajcik & Borko, 1999). Science teaching orientations may be defined as the knowledge and beliefs about the purposes and goals for science teaching held by teachers (Friedrichsen & Dana, 2005). Teaching orientations are personal in nature, stem from the individual teacher's beliefs and may be held consciously or unconsciously (Chan, 2001). Magnusson et al. (1999) identified nine science teaching orientations. Teachers use them "as a 'conceptual map' that guides instructional decisions about issues such as daily objectives, the content of student assignments, the use of textbooks and other curricular materials and the evaluation of student learning" (Magnusson *et al.*, 1999, p. 97). Friedrichsen, van Driel and Abell (2011) notice a growing body of research on pedagogical content knowledge (PCK) based on the science teaching orientations by Magnusson et al. (1999). Some of the research studies based on the nine teaching orientations by Magnusson et al. (1999) reviewed for this paper include Friedrichsen & Dana (2005), Friedrichsen et al. (2011), Nargund-Joshi and Liu (2013), Schuster, Adams Skjold et al. (2014) and Demirdogen (2016).

Some of the studies that used the nine science teaching orientations by Magnusson et al. (1999) as a conceptual framework have been criticised by Friedrichsen et al. (2011) for focusing either on the goals and purposes of teaching science (Grossman, 1999) or on general views about teaching science (Smith, 1987) without defining the science teaching orientations clearly. Similarly Friedrichsen et al. (2011) criticise the assigning of teachers to one orientation. However, some of the studies show that science teachers hold multiple orientations and therefore have clustered the nine teaching orientations into fewer distinct orientations. To this Friedrichsen et al. (2011, p. 372) say that "Based on a sound theoretical framework, empirical studies are needed to determine which distinctive different science teaching orientations exist in practice." For example, Luft and Roehrig (2007) identified five science teaching orientations which are traditional, instructive, transitional, responsive and reform-based. Similarly, Ramnarain & Schuster (2014) and Cobern et al. (2014) used a science teaching spectrum consisting of four categories namely, didactic direct, active direct, guided inquiry and open-inquiry. Friedrichsen et al. (2011) have clustered the Magnusson et al. science teaching orientations into teacher-centred orientations (didactic and academic rigour), orientations based on reform efforts and associated with curriculum projects (process, activity-driven and discovery) and orientation based on contemporary reform efforts and curriculum projects (conceptual change, project-based science, inquiry and guided-inquiry).

There is no doubt that, the nine teaching orientations by Magnusson et al. (1999, p. 97) serve as a strong basis to study science teachers' "conceptual maps" as they make decisions during the teaching and learning process. It is against this background that this study explored science teaching orientations for the integration of practical work in physical sciences classrooms (grades 10-12). In line with contemporary curriculum reform efforts, South Africa introduced a new National Curriculum Statement (NCS) in 2012 referred to as the Curriculum and Assessment Policy Statement (CAPS). The new curriculum embodies the CAPS for Physical Sciences which contains prescribed and recommended practical work activities for formal and informal assessments respectively (Department of Basic Education, 2011). The inclusion of prescribed practical work activities for assessment compels teachers to work through contextual factors that inhibit the integration of practical work to ensure successful implementation. The prescription and recommendation establishes practical work as an integral part of secondary school science (McDonell, O'Connor & Seery, 2007; Hofstein, & Naaman-Mamlok, 2007). However, there is ample evidence in literature to suggest that a significant number of teachers do not find it easy to integrate practical work in the teaching and learning of science (Onwu & Stoffels, 2005; Stoffels, 2005; Webb, 2009). Teachers' failure to integrate practical work into science teaching successfully is attributed to many factors. These include lack of materials and laboratory facilities, lack of sufficient time, teacher identities, intensification of teacher workloads and crowded classrooms (Cheung, 2007, Stoffels, 2005, Christie, Butler & Potterman, 2007, Reid & Shah, 2007). The study contributes to the growing body of knowledge on science teacher teaching orientations by using physical sciences practical work as a context. Friedrichsen et al. (2011, p.373) say that, "We recommend researchers investigate the interaction between science teaching orientations and other PCK components" instead of focusing only on assigning teachers to one or more orientations. The research was guided by the following research question: *What are the science teaching orientations in the context of CAPS for physical sciences prescribed and recommended practical work activities*?

2. METHODOLOGY

A qualitative case study approach was used to explore the science teaching orientations for practical work displayed in the physical sciences classrooms in the context of the CAPS for Physical Sciences syllabus. In this case study the direct participants' experiences were taken at face value (Cohen, Manion & Morrison, 2007). Data to determine the orientations were collected by means of semi-structured interviews with the teachers (audio-taped), lesson observations (video-recorded) and work sheet analysis in cases where these were available. During the semi-structured interviews, the teachers were asked about the nature of practical work activities they facilitated for learners, how they facilitated the activities and about the contextual factors that interfaced with the practical work activities.

2.1 Sampling

The purposive sampling techniques used to select the eight teachers were based on a number of premises. Firstly, the teachers had to come from different school contextual settings to enhance the applicability of the study findings to other contexts and enhance the richness of the data. Secondly, the teachers were supposed to be teaching grades 10, 11 or 12 Physical Sciences and had facilities to engage in practical work. Six of the study sites were located in the city of Tshwane in the Gauteng province of South Africa. These were a former model C (now multiracial schools formerly reserved for Whites before the dawn of democracy), former Indian, former coloured, and an independent schools in central Pretoria, an African township school in Soshanguve and a private school in Hamanskraal. The peri-urban African township and the rural schools were drawn from Bojanala district in the North West province of South Africa

2.5 Data analysis

In order to analyse the data collected a form of inductive qualitative data analysis called constant comparison (Glaser & Strauss, 1967) was used. The data was scanned for categories that were lumped up in themes by comparing, contrasting and establishing linkages (LeCompte & Preissle, 1994). In the final interpretation the findings of the study were integrated with other literature findings. Therefore, the conceptual framework on teaching orientations in science teaching was also used as an analytical framework.

3. FINDINGS OF THE STUDY

After the subjecting the data collected to recursive and constant comparison qualitative data analysis, three themes emerged. The findings of the study are presented below under the three themes

Theme1: Orientations for practical work through teacher demonstrations

Through the teacher interviews it could be surmised that practical work activities were not always facilitated as hands-on activities for learners but as teacher demonstrations. The teacher from the former coloured school, Joseph, said,

I do most of the demonstrations especially when it comes to chemistry. I wish I could do more but then if somehow the children can be made aware that what I'm doing there in front during a demonstration is linked to what is written in the textbook

Susanna in the former model C school also testified to the fact that more teacher demonstrations were conducted than hands-on activities for learners. She said,

I would like to do more but the syllabus is extremely full so we just have to do some of our things as a demonstration because there is no time

The teachers who integrated practical work as demonstrations most of the time included Silas (peri-urban school) and Khulumani (rural school). It can be surmised from the data presented above that through the demonstrations, the teachers aim to transmit and verify scientific facts. The emphasised goals of teaching and learning are both didactic and for academic rigour. However, the rest of the teachers, Melianda, Yolande, Obakeng and Tebogo indicated that they frequently engaged the learners in hands-on activities when it comes to practical work. Melinda revealed how often she engaged the learners in hands-on activities when she said,

It depends on the topic because you find that with this current topic of ions, ion exchange and precipitates you actually do a lot every-day. Let me say every-day I can do two concepts because it's a lot and it’s more interesting when they observe it but the other sections they are more theoretically based. Where it is possible I do a lot of practicals I can say 75%.

The teachers who did not rely on demonstrations most of the time used learner-centred approaches and the activity-driven orientation was evident.

Theme 2: Science teacher orientations for practical work through confirmatory experiments

Learners were also engaged in hands-on practical activities during the lesson observations. Most of these activities had the main objective of confirming the scientific theories, concepts and facts previously taught to learners. Five out of the eight teachers, Susanna, Joseph, Yolande, Silas and Khulumani facilitated verification experiments for the learners. Yolande from the independent school said,

You have to just make sure that you cover the relevant topics and that you have, you need to plant the seeds in their minds while you are teaching the theory like what do you think will happen and why do you think this will happen now when we do the practical it's like now we are going to prove or answer these questions that we had while we were doing the theory sometimes this practical was to prove something

Khulumani from the rural school also stressed why it is important to teach theory first before facilitating confirmatory experiments for the learners. He said,

It’s just having the teacher having done the theory and then we sort of reinforce or enhance that understanding by way of introducing experiments

The inspection of the five worksheets revealed that learners are provided with the aims of the experiment and the experiment procedures that they followed as they made observations and recorded the results. The learners further used the results to arrive at conclusions which served to verify what they already knew. This approach is still didactic and aims at ensuring academic rigour. The academic rigour orientation was revealed when Susanna said,

That’s why we chose the five [experiments to investigate the effect of intermolecular forces on boiling points, melting points, surface tension, solubility and capillarity] because it covers the different aspects of it. And also that it is the type of question that I am anticipating in the exam where they are going to test the theory. So if they can do the practical and they have done the theory and they can put it together now you know it will be a better understanding.

Additionally, as the learners engaged in the hands-on activities they had a chance to develop process skills such as observing, measuring, predicting and communicating. Susanna said the following about the process skills,

Whenever we have a chance somewhere we try to put a practical in. Even if it's boiling water or to give the measurements so that the learners can stay up to date quite a few of them will go to University especially the learners in the science class, quite a few of them will go into engineering and things like that so we have to do practicals and develop that skill for them.

Yolande also reveals how these verification experiments can be used to dispel some misconceptions that learners may continue to have after the initial sessions when they are taught theory. She said, I had taught them everything about what you need for things to conduct electricity and I had taught them about the ionic compounds there are ions and free electrons in metallic compounds and all that. That was not enough they were still confused about it. So what they measure and what they see is quite different from the pictures that they had in their heads so it's a way of getting rid of any misconceptions allowing them to understand what's really happening so it's very invaluable.

It can be seen that through one practical work activity a number of science teacher orientations can be made manifest. Through the verification experiments the teachers displayed didactic, academic rigour, process, activity-driven and conceptual change orientations.

Theme 3: science teacher orientations for practical work through structured and guided inquiry experiments

Through structured inquiry-based practical work activities teachers displayed more science teacher orientations for practical work. Firstly, Obakeng facilitated an experiment as a way of introducing a new topic on Boyle' Law. The learners used their observations to establish the relationship between pressure and volume. Accordingly, the learners were provided with the investigative question and the experiment procedure and they found the solution by discovering the targeted science concepts. In the practical work activity in which Tebogo was observed facilitating for the learners, he gave the learners a problem to design an experiment to verify the facts previously taught about the effect of surface area on rate of reaction. He targeted integrated process skills such as controlling variables, interpreting data and experimenting as instructional goals (Chabalengula, Mumba & Mbewe, 2012). According to Cheung (2007) and Sadeh and Zion (2009) guided-inquiry is one in which learners are provided with an investigative question or problem and they must figure out the experiment procedures and solutions. The problem that Tebogo presented for his learners targeted skills in the syntactical nature science. Similarly, Melinda engaged her grade 11 class in a practical activity in which the learners used their knowledge on solubility to design an experiment to prepare copper (II) carbonate in the laboratory. Additionally, the learners designed an experiment to perform a qualitative analysis of the product of the synthesis. Melinda and Tebogo targeted integrated process skills and knowledge of the syntactical nature of science.

The teachers displayed more than one science teaching orientation as they integrated practical work in the teaching and learning of physical sciences. All the teachers displayed five common science teaching orientations which were didactic, academic rigour, process skills, activity-driven and conceptual change. In addition to the five science teaching orientations one teacher displayed the discovery orientation and two of the teachers displayed the guided-inquiry orientation.

4. DISCUSSION

The study explored the science teaching orientations of physical sciences teachers as they integrated practical work in the teaching and learning process. This was against a background in which practical work was made compulsory for every school context in South Africa due to the presence of prescribed and recommended experiments in the CAPS for Physical Sciences syllabus. It is highlighted in the syllabus that "'Experiment' will refer to a set of outlined instructions for learners to follow in order to obtain results to verify" (Department of Basic Education, 2011). A number of experiments are recommended for verification in the syllabus. In this study it was established that some of the experiments were conducted as teacher demonstrations. Some were facilitated at the confirmatory inquiry, the structured inquiry and guided inquiry levels (Cheung, 2007; Sadeh & Zion, 2009). Demonstrations were teacher-centred approaches in which teachers displayed the didactic and academic rigour science teaching orientations (Friedrichsen et al. 2011). Cobern et al. (2014) say that during demonstrations, teachers present factual knowledge of ready-made science and there are no learner activities. However, Nargund and Liu (2013) contend that teacher demonstrations can be a display of an activity-driven science teaching orientation which might not necessarily target a conceptual change.

Similarly, through the experiments that were conducted at the confirmatory inquiry level the teachers displayed the didactic, academic rigour, activity driven and conceptual change science teaching orientations. Corben et al. (2014) postulate that confirmation experiments in which learners are engaged in hands-on activities are an active-direct science teaching orientation variant based on ready-made science. When learners are engaged in hands-on activities they develop process skills which they use to complete the tasks. Through an experiment at a structured inquiry level one teacher displayed a discovery teaching orientation. Learners were provided with the investigative question and steps of the experiment procedure. The learners were required to use the results of the experiment to find a solution (Cheung, 2007; Sadeh & Zion, 2009). However, more than one science teaching orientations were evident. Learners were engaged in process skills and the orientation was also activity-driven. Finally, two of the teachers displayed a guided-inquiry science teaching orientation for learners to explore and develop knowledge in the syntactical nature targeted at the methods in science.

Physical sciences teachers held multiple science teaching orientations as they integrated practical work activities in the teaching and learning process. The teachers could not be assigned to one teaching orientation (Friedrichsen et al. 2011). In this study all the teachers displayed five of the science teaching orientation by Magnusson et al. (1999) which were didactic, academic rigour, activity-driven, process skills and conceptual change. This study contends that this was the core of the science teaching orientations for practical work integration in Physical Sciences. It was also noted that the teachers who did not use work sheets in this study displayed additional science teaching orientations which were discovery and guided-inquiry. They also engaged learners at higher levels of inquiry which were structured and guided according to the classification by Cheung (2007) and Sadeh and Zion (2009). From the data collected, the project-based science and inquiry science teaching orientations were not observed in the teachers in this study.

5. CONCLUSION

All the teachers in the study displayed multiple science teaching orientations as they integrated practical work in physical sciences classrooms. All the teachers held five common science teaching orientations which were didactic, activity driven, academic rigour, process skills and conceptual change. These were facilitated through teacher demonstrations and experiments facilitated at confirmation inquiry level using work sheets with step by step instructions for learners. The teachers seemed to understand the syllabus as stipulating that the experiments were meant for verification. The teachers who used higher levels of inquiry such as the structured and guided inquiry were able to display additional science teaching orientations which were discovery and guided –inquiry. This study recommends that teachers be supported in order for them to be able to display all the science teaching orientations including the discovery, project-based science, inquiry and guided inquiry.

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