

Andragogical Approach to Teaching and Learning Practical Work in Science: A Case of In-service Training of Teachers

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ABSTRACT Practical work always challenges teachers. The execution of practical work in the classroom is a major challenge. The study reported in this article explores how in-service teachers (adults) acting as learners model practical work in school laboratories. Empirical evidence shows that teachers learn best from one another's lessons. A purposive sample of 46 teachers participated in this study. Eight video recordings of teachers doing practical work in science classrooms were analysed. The results of the study show that teachers can acquire valuable skills through role-play.

INTRODUCTION

The usefulness and effectiveness of practical work in science classrooms at secondary schools is doubted by many researchers, yet science curricula contain significant amounts of practical activities and the necessary resources should be provided to enable teachers to engage learners in these activities. Learners learn by doing and thinking about what they do (Lowery 1994). Thus, the focus should be directed towards facilitating active learning among learners (Coleman et al. 1997). Teachers should constantly model how they teach practical work in science.

Practical work has long played an integral role in secondary school science (Gott and Duggan 2007; Abrahams and Millar 2008; Abrahams and Saglam 2010). In countries with a tradition of practical work in school, science teachers and scientists often see practical work as central to the appeal of science (Abrahams 2009). Many authors (Van der Linde et al. 1994; Bradley et al. 1998; Treagust and Thair 1999; and Abrahams 2009; Kim and Tan 2011) agree that the outcomes of practical work in science focus on the following four broad outcomes: *the reinforcement of the understanding of scientific concepts and principles; the development of practical skills; teaching the processes of science; and stimulating learner's' interest.*

Hodson (1992) believes that practical work in school science has previously been seen as a means of obtaining factual information or data. Many other researchers such as Haslam and Hamilton (2010), Abrahams (2010) and Gyllenpalm et al. (2010) agree that practical work in

schools should assist in the exploration, manipulation and development of concepts and also make the concepts manifest, comprehensible and useful. Hodson (1992) strengthens his argument by stating that experiments should be devised by the learner while the teacher acts as a facilitator. This view is in accordance with theories of motivation, as confirmed by Wigfield (1994), that recommend ceding a greater degree of control over learning to the learner herself. This is in line with the constructivist theory which emphasises that learners should construct their own knowledge. This is sadly not always the case, as Driver (1989) correctly observes that many learners come to science classes with pre-knowledge that is not always acceptable from a scientific point of view. But according to Tamir (1991) and Trumper (2003), practical work can offer learners unique opportunities conducive to identify, diagnose and correct their misconceptions and alternative conceptions. As a result, Trumper (2003) believes that the teachers (and not the learners themselves) should provide experiences and devise innovative ways to help learners confront discrepancies between their own incorrect or limited views and accepted scientific views.

While the call for scientific literacy as a general goal for science education emphasises the need for learners to develop an understanding beyond scientific concepts and skills. According to Gyllenpalm et al. (2010), some researchers such as Hofstein and Cohen (1996), Millar (1991) and Haslam and Hamilton (2010) agree that practical experiences are essential for the development of skills and strategies with a wide range of effects that could be generalised. These

practical skills can be divided into three categories (Millar 1991). The first category refers to general cognitive processes, that is, observing, classifying and stating a hypothesis. The second category includes practical techniques, which could be specific know-how about the selection and use of instruments. The third category, which includes inquiry tactics, is a toolkit of strategies and approaches that could be considered when planning an investigation. These strategies include repeated measuring and taking an average; and tabulating or graphing results in order to identify trends. This means that learners should be helped to improve the use of their creative and critical thinking skills so that they could learn more, learn how to learn and achieve better results.

Eglen and Kempa (1974) wrote about the value of skills in practical work during the 1970s. Their argument is that proficiency in the manipulative skills is generally inferred from the quality of experimental results communicated by the learner to the teacher in the form of laboratory reports. By implication, this practice presupposes that a correlation exists between the proficiency with which a practical task is performed and the quality of the results derived from it.

Tamir (1991) believes that science education should provide learners with real experience of the whole scientific process that is, identifying a problem proposing possible explanations and devising tests to determine the validity of a particular situation. A successful experience in related practical activities may engender feelings of self-esteem, self-confidence and determination that could be transferable to a wider world outside the laboratory. The development of positive attitudes towards science and the scientific enterprise (Woolnough 1991) is among the major aims of science teaching. Koballa and Crawley (1985), Bradley and Maake (1998), Bentley and Watts (1989) and Tamir (1991) concur that practical work can be an effective environment for enhancing learners' attitudes towards an interest in the learning of science.

Objective of the Study

The objective of the study was to investigate teaching and learning strategies that adult learners (teachers) learn during the preparation and presentation of lessons?

RESEARCH METHODOLOGY

A purposive sample of 46 ACE (Advanced Certificate in Education) in-service or part-time science teachers at a single, urban university in South Africa participated in this study. The teachers were teaching Grades 10 to 12 in the FET (Further Education and Training) band in their respective schools. Subjects taught by this group of teachers included physical science and mathematics. The highest qualification possessed by these teachers was a three-year diploma in education, majoring in physical science and mathematics.

There are four contact sessions of between five and ten days per year. The ACE programme runs over two years. The study was done during the first four contact sessions of the teachers' two-year programme. An assignment was given to teachers during the first contact session. In this assignment, the teachers were requested to prepare a lesson plan on Ohm's law incorporating a practical component. It was indicated that their lesson plans had to indicate clearly the outcomes of the practical component of their lessons. The teachers were given two months to complete the assignments. The assignments were posted to the researcher.

During the second contact session, individual efforts were combined to prepare lessons in small groups. The 46 teachers were then asked to divide themselves into six groups. The first and second group consisted of seven members each, the third group consisted of nine members, the fourth group consisted of seven members and the fifth and sixth group consisted of eight members each. One teacher in each group presented the lesson while the others acted as learners. Teachers presented the lessons and their presentations were recorded on video. The recorded lessons were viewed several times and discussed with teachers during the second and third contact sessions.

In the fourth contact session, the presenters of six lessons were requested to prepare a "model lesson" and choose a representative to present the lesson. The "model lesson" was also recorded on video. The teachers and researchers viewed the model lesson together and discussed it. The discussion was facilitated by the researchers. All the recorded lessons were then transcribed for analysis and coding. A questionnaire was given to teachers to gauge their perceptions of the re-

corded lessons as a teaching tool and also their perceptions of the intended outcomes of practical work.

Theoretical Framework

The paper is positioned in both adult learning theories and constructive development theories, which shed light on adult development and growth in order to support the development of adults' knowledge and skills (Grado-Severson 2007). There are several theories that inform and guide adult learning. These theories include andragogy, which is the art and science of helping adults learn (Knowles 1980: 42). The roots of andragogy can be traced back to Alexandra Kapp, a German grammar teacher who used the term to describe Plato's educational theory (Knowles et al. 1998: 59). In 1921, a German, Eugene Rosenstock maintained that adult education requires special teachers, special methods and a special philosophy (Knowles et al. 1998: 59). Although the term "andragogy" has been used since the 1930s in Europe, Malcolm Knowles became its pioneer. Knowles defined the concept of andragogy as the art and science of how adults learn, conflating it with pedagogy, the art and science of helping children learn (Merriam and Caffarella 1999: 272).

Drawn from the theory of andragogy, the following guidelines were pertinent and essential to the current study since it involved in-service training of teachers:

- Adults strive to be self-directed.
- Adults enjoy planning and contributing to their own learning experiences.
- Adults bring extensive experience to the learning situation.
- They always look for ways in which they may transfer their previous learning to the new situation, which increases their sense of self-worth and confidence.
- Adults' readiness to learn is oriented to the task they perceive as inherent to their social and professional roles.
- Their focus is more performance centred than subject centred (Brockett and Himstra 1991: 2; Jones and Walters 1994: 160; Speck (1996); Lambert 1996: 43; Furajic 2000: 62- 63; Knowles et al. 2005: 159).

The first guideline is self-directed learning, that is, the ability of adult learners to take control of the techniques and purposes of learning.

The second guideline is the learner's need to know "how learning will be conducted, what learning will occur and why learning is important" (Knowles et al. 1998: 133). The third guideline implies that the prior experience of adult learners has an impact on learning by creating individual differences, providing rich resources, creating biases and providing adults' self-identity. The fourth guideline is motivation to learn. Adults are highly motivated to learn when the new knowledge can help them to solve important problems in their lives. The fifth guideline is readiness to learn. This implies that adults become ready to learn when their life situations create a need to learn. The sixth guideline is orientation to learning: adults prefer a problem-solving orientation. In this case, adults can learn best when knowledge is presented in a real-life context.

Brookfield (1995: 2) explores four exclusive adult learning processes. Firstly, self-directed learning focuses on the process adults follow to take control of their learning and formulate their goals. Secondly, they look for accessible and adequate resources that would enable them to exercise control over their learning more readily. That is, they decide on their learning styles and evaluate their progress. Thirdly, experiential learning is such that adult teaching should be based on adults' experiences. Those experiences could be a valuable resource. Finally, learning to learn is very crucial for adult development. When adults become skilled at learning, they have the ability to become lifelong learners.

Adults bring numerous life and work experiences, needs, personalities and learning styles to their learning, and all these elements shape their perspectives on learning, education and professional development (Grado-Severson 2007). Adult learning involves the experiential learning. Kolb (1984) has been a proponent of advancing the practice of experiential learning. The four steps below are an invaluable framework for designing learning experiences for adults:

- Concrete experience – full involvement in new here-and-now experiences.
- Observation and reflection – reflection on and observation of learners' experiences from many perspectives.
- Formation of abstract concepts and generalisation – creation of concepts that integrate the learners' observations into logically sound theories.

- Testing of new concepts in new situations – using these theories to make decisions and solve problems (Knowles et al. 2005: 197).

Experiential learning occurs as a result of a learner transforming his or her experiences into knowledge (Merriam and Caffarella 1999: 226). Therefore learning will only take place if the learner's experience is engaged at some level. This implies that the situation approach to education is tantamount to giving the learning process a setting of reality from the outset (Leonard 2002: 4-5). It involves observation, discovery and collaborative inquiry or discourse through shared experience (Amstutz 1999). The recorded lessons were developed in the hope that teachers would learn from experiences which shaped their views about the world (Cunningham and Cordeiro 2003: 191). The experiential learning approaches can offer the double advantage of appealing to the adult learner's experience base, but also increase the likelihood of performance change after training (Knowles et al. 2005: 199), in light of which in-service trainers need to design in-service training that draws on the practical experiences of teachers. For instance, in-service training can be effective if the trainers can provide a problem-solving process and ask the learners to give a case study from their experience (Moseley and Dessinger 2007: 210). This implies that the training should take into account the teacher's experiences.

John Dewey is considered to be the founder philosopher of constructivism (Huitt 2003: 1). Constructivism is an approach to cognitive development in which learners discover all knowledge about the world through their own activity (Berk 2000: 645; Bently and Watts (1994: 8/1989) write that constructivism is

...a philosophy and psychology about the way people make sense of the world. The central point is that people are always intellectually active – they do not learn passively, but go out of their way to try to make some meaning in what is taking place in the environment.

Therefore constructivism does not represent a single unified theory on its own, but it is a group of perspectives that are related to one another (Nesbit et al. 2004: 81). Influences of behaviouristic, cognitive, humanistic and social learning theories are present in the different constructivist views (Nesbit et al. 2004: 81). Much of adult learning theory is constructivist

in nature (Merriam et al. 2007: 293). Constructivism represents the most recent views on adult learning (Gravett 2001: 17). Here are some of the applications of constructivism to adult education (Knowles et al. 1998; Huang 2002).

- Adults want to learn about relevant topics.
- Adults utilise previous knowledge to create understanding.
- Adult education settings need a flexible curriculum to adapt to the audience.
- Adults are mostly self-directed learners.
- Constructivism allows adults to develop their own understanding and meaning of information which can make it more useable.
- Adults do not want to be lectured to; they tend to prefer problem-solving types of situations.
- Adults want to be in control of their learning experiences.

The constructivist view of learning is particularly compatible with the notion of self-direction since it emphasises the combined characteristics of active enquiry, independence and individuality in a learning task (Candy 1991: 278). Constructs, like schemata, help the learner understand what to expect as well as how to select and process incoming information (Carlson and Maxa 1998: 52). In constructivism, learning is not a fixed object, it is constructed by an individual through his or her own experiences of that object (Dolittle and Camp 1999: 17; Hsiao 2007: 3). The relevance of the constructivist theory in this study lies on the premise that adult learners are also expected to construct their own knowledge. The authors are of the view that if adult learners (teachers) can be able to construct their knowledge from a practical activity. They should be in a position to prepare their practical activity such that the learners they teach can be able to construct knowledge from the practical activity.

RESULTS AND DISCUSSION

The central role of experience in adult education is another point of contact between adult learning and constructivism. Constructivist learning theory suggests that learning is a constructive process in which the learner forms an internal picture of knowledge, a personal interpretation of experience, and engages in a "sense-making process where the individual builds new

knowledge and understanding from the base of existing knowledge and perceptions” (Chalmers and Keown 2006: 148). Andragogy and other models of adult learning see life experience as both a resource and a stimulus for learning. Constructivism too begins with the learner’s interaction with experience (Merriam et al. 2007: 293). In line with constructivist approaches, practical work as operationalised by teachers in the recorded lessons indicated the aspects of professional development highlighted below (Chalmers and Keown 2006; Wenger 2007; Hodkinson and Hodkinson 2007):

- The social and distributed nature of cognition. In this regard, teachers learn best when they work in a community characterised by action and dialogue. This was demonstrated through the discussion and viewing of recorded lessons. In these discussions, teachers could express their views regarding recorded lessons. One of the teachers said: *“previously I used to do a lot of demonstrations. I was a lesson leader and guided learners a lot, but now I have learnt that the teacher should use a problem based approach.”* This confirmed the fact that, through role play, teachers can learn a lot from each other.
- With one of the teachers commenting that: *“After having presented a lesson and looked at myself, I realised that I did not give learners sufficient support as far as assisting and guiding them. Now I realise that spontaneous facilitation in a lesson can be well managed and outcomes achieved.”* The teacher’s responses indicate that they have learnt new approaches, skills, knowledge and tactics. These contributed towards their professional development which is can be useful to actual situations and the contexts of individual schools.
- However, sufficient time is needed for professional training purposes. With enough time, new developments and effective change can take place. Unfortunately short courses, while being worthwhile in other ways, do not allow time for the four elements of the constructivist approach.

According to teachers the discussion of the lessons prior to presentation and after presentation of the lessons helped to discover my weak points. Teachers were excited about the experi-

ence of joint preparing a lesson. One of the teachers said that: *we shared ideas and came up with one matured lesson.* They pointed out that the lessons gave a clear picture of what has to be done in practical work. The opposing views of teachers regarding the merits and demerits of the lessons was a learning curve for many teachers. Even though many were excited about the lessons, some of them indicated that it was embarrassing to see themselves making mistakes. However the teachers learnt from those mistakes.

In order to improve on the lessons, teachers were asked to indicate the negative things about their experience with the lessons presented. Teachers pointed out that, these lessons can mislead the viewers because the lesson involves a small group of teachers. This is because, many of teachers who participated in this study taught large classes in their respective secondary schools. They argued that it may not be possible to implement the same teaching and learning strategies to large classes. Their challenge was to implement what they have learnt in their respective schools.

Notwithstanding the fact that teachers were given sufficient time to prepare, some teachers complained about the limited time allocated to preparation and presentation of the lessons. Teachers wanted more time to prepare and present the lesson. With regard to role playing, teachers said that the role playing learners help them to experience the challenges that learners face in the classroom.

Reflective practice and communities of practice are found in both adult learning and constructivism (Merriam et al. 2007: 293). Viewing the lessons on video gave teachers an opportunity to reflect on their lessons. In accordance with adult learning and constructivism, the results of this study suggest that teachers should be given responsibility for shaping their own lessons. This is because they have control over the learning situation, they will be more willing to take risks. In addition, the adult learner is described as having a clear sense of purpose and the ability to be more involved in in-service training (Knowles et al. 2005). Hence, institutions tasked with training adult learners need to update and upgrade their existing skills and attitudes and acquire new ones that will enhance their ability to deal with different challenges that accompany adult training (Moore 2000: 127).

CONCLUSION

The researchers of this paper have been informed and influenced by the theory of andragogy and its application to practical work in science. In view of the benefits of doing practical work in schools and having reviewed the eight lessons presented by teachers, several conclusions can be drawn. This paper offers a new approach to practical work within the andragogical paradigm. The authors suggest that teachers should do practical work themselves before doing it with learners. It is hoped that in the process of fine-tuning their skills, valuable skills in the teaching and learning of practical work can be acquired. Ultimately, there will be improvement in how they present practical work in a science classroom. The study concludes that role modelling can assist in the professional development teachers. These include discussing and sharing ideas about a presented lesson, with the aim of improving teaching and learning strategies used in practical work. Modelling practical lessons according to andragogy emanates from the view that schools learners are taught by "adult" learners. Hence, if we understand how adult learners learn and do practical work in science we could find ways of improving our teaching and learning strategies to suit secondary school learners.

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