PRESERVICE TEACHERS' REFLECTIONS ON TEACHING SCIENCE WITH PRACTICAL WORK IN MULTIPLE-DEPRIVED CLASSROOMS

Maria Tsakeni
University of the Free State (Qwaqwa Campus)
tsakenim@ufs.ac.za/ mtsakeni@gmail.com

ABSTRACT – Practical work is central to science education because it has several affordances for teaching and learning. Preservice science teachers may learn to facilitate practical work in schools during teaching practice. However, it is important for teacher training programmes to establish what the preservice science teachers learn about teaching science with practical work in the schools. Most of the science classrooms in the schools are characterised by challenges that result in conditions of multiple-deprivation for teaching and learning. Using a pedagogical content knowledge conceptual framework for science teaching, this study explored the teaching of science with practical work in schools through the reflections of five final year preservice physical sciences teachers at one South African university. In a qualitative case study of teaching science with practical work in multiple-deprived classrooms, purposive sampling was used to select the preservice science teachers. The data collection tools were the preservice teachers' reflection journals completed during practicum. The preservice teachers reflected on how science was taught with practical work in the multiple-deprived classrooms and on how they could improve the practices. Findings point to reflection as a potentially powerful tool for preservice science teachers to develop positive attitudes and perceptions on key aspects of the pedagogical content knowledge for science teaching with practical work. In addition, the study identifies knowledge and beliefs of science classroom contextual settings as aspects of the pedagogical content knowledge for science teaching with practical work. Recommendations for practice are made.

Keywords: multiple-deprived classrooms; practical work; preservice teachers; teaching science; reflections

INTRODUCTION

Practical work activities are inherent in school science curriculums. However, teachers are generally reluctant to teach science with practical work due to a number of factors (Kim & Tan, 2011). Some of the known factors that discourage teachers are time constraints, lack of materials, curriculum demands and limited teacher pedagogical content knowledge. In this paper, I posit that the factors discouraging teachers to teach science with practical work create multiple-deprived classrooms. Multiple-deprivation is a social condition resulting from an accumulation of single domains of unmet needs (Noble, Zembe, Wright & Avenell, 2013). Ramnarain (2014) studied multiple-deprived conditions for inquiry science learning in South Africa. The findings indicate that teacher-centred instructional strategies, large classes, lack of resources and absence of inquiry-based learning characterise multiple-deprivation. These conditions were more pronounced in township and rural schools. Preservice science teachers are expected to experience similar conditions in their future classrooms. Accordingly, teacher-training programmes should strive to prepare preservice science teachers for practical work facilitation in all school contexts to avoid the creation of multiple-deprived classrooms for practical work. Teacher training programmes need to be sensitive to preservice science teachers' experiences in teaching science through work-integrated learning (teaching practice). Preservice teachers' teaching practice experiences may be used as data to improve teacher-training practices for science teaching with practical work. One way of collecting data on preservice teachers' experiences of opportunities to learn during teaching practice is through eliciting their reflections. The research question for the study is: How do preservice science teachers learn to teach science with practical work in multiple-deprived classrooms through their reflections of teaching practice experiences?

THEORETICAL BACKGROUND

Practical work is pivotal in science education. It can be used as an instructional strategy to facilitate the learning of scientific knowledge (Millar, 2004). In addition, it forms part of the scientific knowledge that is learnt through other instructional strategies. Wei and Liu (2018) point out that, teachers through demonstrations and experiments by learners, can facilitate practical work. However, Millar (2009) explains that practical work activities vary in nature by what they ask learners to do and what they try to teach to learners. The activities may also vary in complexity from simple theory confirmation to open-ended investigations. The Department of Basic Education (2011, p. 11) echoes this when it says: "Practical work must be integrated with theory to strengthen the concepts being taught. These may take the form of simple practical demonstrations or even an experiment or practical investigation." Practical work may also be used to achieve other broader science education goals such as the development of inquiry skills in learners. The result is a growing list of instructional strategies for practical work. Inquiry-based practical work is one example of an instructional strategy in tandem with inquiry-based science as a broad science educational goal. It can be safely concluded in this section that science teachers and preservice teachers alike need to develop significant knowledge in order for them to be able to teach science with practical work. This significant knowledge also needs to be adapted to a variety of schooling contexts including the multiple-deprived classrooms. Consequently, this study uses a pedagogical content knowledge lens to explore the knowledges of teaching science with practical work in multiple-deprived classrooms through preservice teachers' reflections.

Conceptual framework

The pedagogical content knowledge (PCK) concept by Shulman (1987) is applicable to a wide range of classroom situations to explain teacher knowledge. The PCK concept has received significant research attention that forms the basis for further conceptualisations of teacher knowledge. A case in point is the topic-specific pedagogical content knowledge (TSPCK) by Mavhunga and Rollnick (2016). The implication is that whilst teachers are required to possess significant PCK to be professionals, they are also expected to possess specialised PCK concomitant with the subjects they teach and the different topics in the subject areas. Significantly, the development of PCK for science teaching is very important for those who aspire to be science teachers. Grossman (1990) and Magnuson, Krajcik and Borko (1999) formulated five key aspects of PCK for science teaching. First, teachers display particular orientations when teaching science. Second, teachers possess varying degrees of knowledge and beliefs about learners' understanding of specific science topics. Third, teachers possess knowledge and beliefs about the science curriculum. Fourth, teachers possess knowledge and beliefs about instructional strategies for teaching science. Fifth, teachers possess knowledge and beliefs about assessment in science. The use of TSPCK results in operationalising teacher knowledge in terms of practical work. In this study and as suggested in Wei and Liu (2018), teacher knowledge for practical work has been adapted accordingly. The five teacher knowledge domains used are (i) orientations for practical work, (ii) knowledge and beliefs about learners' understanding of practical work, (iii) knowledge and beliefs about the practical work curriculum, (iv) knowledge and beliefs about instructional strategies for practical work, and (v) knowledge and beliefs about the assessment of practical work. This framework for PCK will be used to make sense of teaching science with practical work through the preservice science teachers' reflections.

STUDY CONTEXT AND DATA COLLECTION

This study was conducted as a qualitative case study. Creswell (2007) defines a case study as a bounded system defined by particular parameters. In light of this, the phenomenon explored in this study defined the case. The phenomenon explored was the preservice science teachers' perceptions of teaching science with practical work in multiple-deprived classrooms. The study was designed around a final year preservice teachers' Bachelor of Education (Bed) physical science teaching practice course at one university in South Africa. The teaching practice course lasted for 14 weeks. During the teaching practice, the preservice science teachers had opportunities to plan lessons and teach secondary school learners (Grades 8-12). The preservice teachers also had opportunities to learn from teacher mentors through lesson observation and other relevant activities. Purposive sampling ensured that the selected preservice teachers were in schools with multiple-deprived science classrooms. The schools were all situated in rural parts of QwaQwa in the Free State Province of South Africa. The participating preservice teachers were provided with a semi-structured reflection guide before they left for teaching practice. The reflection guide ensured that the preservice teachers documented the school and classroom contextual settings with the aim of describing the conditions of multiple-deprivation. The guide also enabled them to describe the teaching of science with practical work in the classrooms. They noted the instructional strategies used for teaching science with practical work. The participants were also asked to freely critique the lessons taught in terms of strengths and weaknesses. Finally, they were asked to describe how they could improve the lessons if they were to conduct them in future. The study was part of a larger, design-based study that had already been ethically cleared by the university and the reflection guide was one of the assessment tools used by the methods course to assess the preservice physical sciences teachers during practicum. Therefore, permission was sought from the purposively selected sample of participants to use their reflections.

Participants

The participants were five final year preservice physical science teachers from a 4-year BEd programme. The students were assigned pseudonyms PPT 1-5 (Physical sciences preservice teacher 1-5). The participants were invited through a call made by the researcher that asked for permission to use their reflections for this study. Twenty students consented to participate in the study. However, five participants were selected after an analysis of their reflections. The selected reflections met the requirements of purposive sampling in which practical work was conducted in multiple-deprived classrooms. The multiple-deprivation conditions relevant included shortages of materials for practical work implementation and negative teacher attitudes towards the use of practical work. The reflections in which the preservice teachers considered the use of practical work effective were avoided.

Data analysis

Thematic analysis, using directed content analysis, was used to organise the findings into five themes in relation to the reflection instrument. The themes were (i) conditions of multiple deprivation identified by the preservice teachers, (ii) how science was taught with practical work, (iii) nature of practical work used to teach science, (iv) improvisation strategies in multiple deprived classrooms, and (v) preservice teachers' suggestions to improve practical work facilitation. The preservice teachers were required to write their reflections under each of those guiding themes. The themes also guided data analysis and presentation.

Results

The most representative excerpts from the five preservice physical sciences teachers were used under each theme. The researcher did not see the need to write down the reflections of all the five preservice teachers if they were repetitive.

Conditions of multiple-deprivation identified by the preservice teachers

The preservice teachers highlighted time constraints and the lack of materials as major challenges in the multiple-deprived classrooms. PPT5 said, "Due to time and unavailability of materials we didn't do some of the practical work activities, because when we were busy choosing materials that we needed to replace or checking for materials. It consumes time so we ended up not having enough time to perform practicals." Time constraints also came up as one of the conditions experienced in the multiple- deprived classrooms. In addition, PPT2 said, "The class had a large group of learners, and the materials were limited. The teacher had to divide the class into groups of 10. Not all the materials were available in the lab. The teacher had to buy some of them, from his own pocket; things like cooking oil, acetone -and glycerine." In confirmation of what PPT2 said, "I could see that some of the classrooms were overcrowded and the teachers had to go an extra mile by using their personal money to buy some of the materials."

How science was taught with practical work

I selected reflection excerpts from PPT1, PPT2 and PPT4 that summarised how science was taught with practical work in the multiple-deprived classrooms. First, in some instances the teachers just described the experiments and the expected results to the learners. PPT1 confirmed: "We just went through the procedure and steps in the textbooks and constructed the experiment in our mind and suggested the possible results especially on distillation and filtration." Second, some of the practical work activities were facilitated for the learners. As reported by PPT2, the teachers were demotivated by the conditions of multiple-deprivation in the classrooms. PPT2 said, "Only 3 activities were implemented without any challenges, the 4th experiment could not be implemented because of the lack of motivation on the teacher's part and the materials were not available; those that were available were outdated." Third, whilst PPT4's reflection corroborated what PPT1 and

PPT2 had said, he added that teachers sometimes showed learners videos of the experiments. PPT4 said, “For the practical work activity that was not implemented I think, the teacher was pressed for time and because he felt that is a repetition of the ones he had done already. The teacher showed the learners a video demonstration of the practical work.” Practical work was also in the form of demonstrations and required learners to record the observations. PPT5 said, “Since we had limited materials every learner observed as the teacher demonstrated and followed the procedure step by step. They recorded every observable change during the experiment demonstration, for instance where ice was heated to gas (water vapour) and they had to record temperatures of the solid, liquid and gas states.”

Nature of practical work used to teach science

The practical work activities described by the preservice teachers were conducted as experiments. PST4 said, “Scientific method[s] where learners had to construct their own hypothesis and construct the experiment were used.” There was no indication of any other form of practical work besides the experiments from all the five PPTs. However, the learners had some experiences of the nature of science.

Improvisation strategies in multiple-deprived classrooms

The preservice teachers’ reflections also showed that the teachers found ways of improvising when materials for certain practical work activities were lacking. PPT5 affirmed: “We had to replace unavailable materials with relevant available materials; for a burner we used candles and for a tripod we used bricks and a gauze, and for a petri-dish we used the lid of Frisco tin. It was a stupid idea, but at the end learners understood and they were able to check whether their hypothesis was accepted or rejected.” Initially, the preservice teacher considered that improvisation of materials may not quite serve the purpose effectively, however in this case she subsequently realised that it did. Videos were also used in place of actual hands-on practical work activities. PPT3 said, “The practical work was not implemented due to shortage of materials and equipment to perform the experiments so my mentor teacher would first look for a related topic with the practical [work] on the internet and I downloaded the video then I took it to the school library projector and connected it to the classroom with power. I called the learners to watch the video for them to get some understanding of what was expected of them when answering questions about the practical activity.” These videos were just for learners to watch and not for the learners to manipulate variables.

Preservice teachers’ suggestions to improve practical work facilitation

The preservice teachers thought that teachers could use other resources outside the school to ensure that learners were exposed to practical work facilitation. PPT1 said, “Since there are centres of Maths, sciences and technology I will plan a trip where learners will have a chance to conduct different experiments and they will have time to ask questions and construct their own understanding from the facilitators at the centre. They will also be given a chance to conduct at least two of the experiments on their curriculum.” The preservice teachers believed that teachers should be able to identify household materials that could be used to replace some of the prescribed materials for practical work activities. They also thought that the use of videos by both teachers and learners could help them to see how some practical work activities should be conducted before they engaged in hands-on activities. They also felt that the teachers should attend workshops on how to teach science with practical work. PPT2 summed up the role of the workshops when she said:, “To teach them to improvise, to look for and find the appropriate materials that are used in households e.g. acetone for nail polish remover and to use them as substitute materials. They should give them in-depth content and knowledge about the subject matter. They should be made to watch exactly the same video of the practical work so they know how to conduct it themselves. By doing thorough research about the topic that is troubling, by workshopping them on the how to deliver them and then make them conscious of the importance of practical work in teaching and learning.”

DISCUSSION AND CONCLUSION

The study set out to explore how preservice teachers learn to teach science with practical work in multiple-deprived classrooms through their reflections of teaching practice experiences. On comparing the conceptual framework for the study, which is PCK for practical work (Wei & Liu, 2018) with the findings it can be concluded that the preservice teachers gained some forms of knowledge and beliefs of teaching science with practical work in multiple-deprived classrooms. As a science teacher educator, I took note of what they learnt and what they were not able to learn from the teaching practice experiences. The preservice teachers could develop both positive and negative attitudes and perceptions in teaching science with practical work. First, of the forms of practical work, the preservice teachers learned to facilitate experiments. They did not mention other types of practical work. The perception developed out of this experience could be negative because it can limit their knowledge of practical work. Second, the preservice teachers their mentors in the multiple-deprived classrooms improvise when prescribed materials for practical work were not available. This observation created a positive perception that it is possible to facilitate practical work for learners in classrooms that lack materials. Third, the preservice teachers also observed the in-teachers failing to facilitate practical work activities for learners. However when asked how practical work facilitation could be improved in multiple-deprived classrooms, the preservice teachers understood that something could be done and they were able to provide alternative ways of ensuring that science was taught with practical work for learners. In conclusion, this study identifies a form of knowledge in addition to the PCK already defined in literature for teaching science with practical work.

In addition to the teacher knowledge and beliefs for science teaching (Grossman,1990 & Magnuson *et al*.,1999) and accordingly, knowledge and beliefs for practical work (Wei & Liu, 2018) which are the five knowledges discussed under the conceptual framework section above, preservice teachers also developed knowledge and beliefs for teaching science in multiple-deprived classrooms. The preservice teachers developed knowledge for classroom settings that influenced the decisions they made for teaching and learning. Hence, this study contends that knowledge and beliefs for science classrooms' contextual settings (multiple-deprived or not) are part of the knowledges that the preservice science teachers should develop. The knowledge should include how practical work can be implemented under different classroom settings. This knowledge should be augmented by the knowledge of different ways to conduct practical work in science so that the teachers' perceptions of practical work are not limited to experiments. Knowing the different forms of practical work would assist the teachers to provide alternative practical work activities in different classroom settings. In addition, the study recommends that, preservice teachers' reflections of practicum experiences can be used as a form of feedback of the experiences and learning opportunities for preservice science teachers on teaching strategies such as practical work. The reflections can be used as a feedforward for subsequent preservice science teacher preparation.

ACKNOWLEDGEMENTS

The study was funded by a Thuthuka Funding Instrument for the NRF (South Africa) Rating Track.

REFERENCES

Creswell, J.W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage.

Department of Basic Education (DBE). (2011). *Curriculum and Assessment Policy Statement. Grades 10-12. Physical Sciences.* Pretoria: Government Printing Works.

Grossman P. L. (1990). *The making of a teacher: teacher knowledge and teacher education*. New York, NY: Teachers College Press.

Kim, M. & Tan, A.L. (2011). Rethinking difficulties of teaching inquiry-based practical work: Stories from elementary pre-service teachers, *International Journal of Science Education*, 33(4), 465-486.

Koc, I. (2012). Preservice science teachers' reflect on their practicum experiences. *Educational Studies*, 38(1), 31-38.

Magnusson S. J., Krajcik J. & Borko H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. in Gess-Newsome J. and Lederman N. G. (ed.), Examining pedagogical content knowledge: the construct and its implications for science education, Boston: Kluwer, pp. 95–132.

Mavhunga, E. & Rollnick, M. (2016). Teacher- or learner-centred? Science teacher beliefs related to topic specific pedagogical content knowledge: A South African case study. *Research in Science Education*, 46, 831-855.

Millar, R. (2009). *Analysing practical activities to assess and improve effectiveness: The Practical Activity Analysis Inventory (PAAI).* University of York: Centre for Innovation and Research in Science Education, Department of Educational Studies

Noble, M., Zembe, W., Wright, G., Avenell, D. (2013). Multiple deprivation and income poverty at small arealevel in South Africa in 2011.Cape Town: SASPRI.

Ramnarain, U.D. (2014). Teachers' perceptions of inquiry-based learning in urban, suburban, township and rural high schools: The context-specificity of science curriculum implementation in South Africa. *Teacher and Teacher Education*, 38, 65-75.
Shulman L. S. (1987). Knowledge and teaching: foundations of the new reform. Harvard Educ. Rev., 57(1), 1–22.
Wei, B. & Liu, H. (2018). An experimental chemistry teacher's practical knowledge of teaching with practical work: the PCK perspective. *Chemistry Education Research and Practice,* 19, 452-462.