An Analysis of Pre-Service Science Teachers’ Perceptions of Science Teacher Preparation through Open and Distance Learning

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Abstract

The Zimbabwe Open University (ZOU) prepares secondary science teachers through Post Graduate Diploma in Education (PGDE) open distance learning (ODL). This is done in partnership with secondary schools, where pre-service teachers do attachment teaching practice (ATP). In this study, pre-service teachers are individuals who do not have professional teaching qualifications (temporary teachers), but are holders of non-teaching science degrees like Bachelor of Science (BSc) and Bachelor of Science Honours (BSc Hons). The PGDE prepares holders of these degrees to be Science Education teachers. The population in the study is comprised of pre-service science teachers at ZOU Regional Centre “P”. Participants were purposively and conveniently sampled. Through interviews and document analysis, the study investigated the extent to which ZOU prepares science teachers to produce secondary school graduates with science and technology (S&T) attributes relevant to Zimbabwe. Interview data was analysed through thematic analysis, while data from analysis of documents was compared to establish convergence and divergence among policy and curriculum issues. Findings show that ZOU is contributing greatly to the national objective of increasing the number of science teachers. While pre-service teachers had good subject content mastery, ‘the how to teach the subject content’ or science pedagogical content knowledge (SPCK) was weak. Therefore, improvement of pre-service science preparation in SPCK is needed, in order to produce desired S&T learner outcomes in schools.

Keywords: Open & Distance Learning, pre-service teachers, science pedagogical content knowledge.

Background

Science education is considered vital because it constitutes a solid foundation for sustainable development, in a science and technology (S&T) society (Maringe, 2005, p.1). In order to use science education to achieve developmental goals, many countries are putting focus on the quality of preparation of science teachers (European Union, 2015, p.6). The importance of well-trained science teachers for preparing students to function effectively in an increasingly science and technology environment is the concern of science teacher preparation programmes (Sordat, 2009, p.7). Development of S&T skilled human resources has its foundation in science education, which should begin at primary school level and then be strengthened at secondary and tertiary levels (Zimbabwe, 2012, p.5). This perspective resonates perfectly with the goals of inclusive education, which advocate that all learners benefit fairly from education. Therefore, science education is an important component of the school curriculum, which every learner should experience, in pursuit of both S&T and inclusive education global goals (ZIMSEC, 2013, p.3). Science education provides opportunities for an individual and the nation...
to stay competitive in the world of science, technology, engineering and mathematics (STEM) (Dorsey, Park & Howard, 2013, p.1). For Zimbabwe this is the opportune time to implement STEM goals because the government is putting a lot of thrust in this direction. This is shown by the high level of advocacy, by both the Ministry of Primary and Secondary Education (MoPSE) and the Ministry of Higher and Tertiary Education, Science and Technology Development (MHTESTD).

Rationale for ODL in Science Teacher Education

Global trends show increasing demand for teachers. This is attributed to increasing school enrolments, teachers who are leaving the profession and teachers who are retiring. Conventional teacher preparation institutions cannot cope with the increasing demand for teachers, hence alternative means are being used to augment teacher preparation (Mushayikwa, 2006, p. 2; Mhishi, Bhukuvhani & Sana, 2012, p.73). Kangai & Bukaliya (2011, p.125) acknowledge that the high demand for teachers has resulted in many countries in Sub-Sahara Africa adopting innovations that call for a paradigm shift from traditional models of teacher education. One of the innovations, aimed at improving the quantity and quality of teachers, is the use of open and distance learning (ODL) in teacher development (Mushayikwa, 2006, p.2; Mhishi; Bhukuvhani & Sana, 2012, p.75). ODL has the potential to give many people access to education due to advances in technology which has made teaching from a distance possible (Malaysiaisan Qualification Agency, 2011, p.3). This justifies the use of ODL in preparing sciences teachers in an attempt to meet demand.

Concept of a pre–service teacher

In this study, pre-service teachers are individuals who do not have professional teaching qualifications, but are holders of non-teaching science degrees like Bachelor of Science (BSc) and Bachelor of Science Honours (BSc Hons). In addition, these teachers have not been appointed into the Service by the Civil Service Commission, which employs teachers and all civil servants in Zimbabwe, so they are referred to as temporary teachers. The PGDE prepares holders of these degrees to become Science Education teachers.

Rationale for the ZOU PGDE

Since the beginning of the 21st century, governments worldwide are implementing measures to cut expenditure. As a result training as a teacher in conventional institutions has attendant challenges, which include high cost of fulltime studies and difficulty in getting paid manpower development leave. In addition, there is lack of accommodation and classrooms in centralised university systems (Boitshwarelo, 2009, p. 1; Sampong, 2009, p.1). This makes the ZOU PGDE ODL an appropriate way of preparing teachers, more so when Zimbabwe is experiencing challenges related to an economic meltdown during the second decade of the 21st Century.

Motivation for the study

The present study was triggered by the desire to understand how ZOU is developing teachers to meet the expectations of the Second Science, Technology and Innovation (STI) policy of Zimbabwe and the thrust of STEM implementation in education. Both the First Science and Technology Policy of Zimbabwe and the Second STI Policy of Zimbabwe (Muchena, 2003; Zimbabwe, 2012, p.5) acknowledge the dependence of the capacity of a country to be innovative on the use of S&T, on the availability of appropriately educated and skilled human resources, and infrastructure. These documents further show that the base for the development of human resources with S&T skills are
secondary school graduates with a good science education background. Namunga and Otunga (2012, p.229) observe that the quality of science education that learners receive depends on how science teachers are trained during the pre-service phase. Premised on this, the issue which came into mind of the researcher was the desire to understand how ZOU is training teachers to meet the expectations of the STI policy of Zimbabwe, and the thrust of STEM implementation in education. Therefore, this study focused on the ZOU PGDE programme, guided by the following research questions:

1. What are the perceptions of pre-service science teachers in the ZOU PGDE programme of their preparedness to teach science at secondary school level in Zimbabwe?
2. What challenges are faced in the preparation of pre-service science teachers in the ZOU PGDE programme?
3. How could pre-service science teacher preparation in the ZOU PGDE be improved?

**Methodology**

The qualitative methodology used in this study involved the use of a case study design. Both the methodology and the design were relevant because they allowed the researcher to explore the perceptions pre-service science teachers in the ZOU PGDE programme at Regional Centre P hold of their preparedness to teach science at secondary school level in Zimbabwe. Use of more than one data collection technique (interviews and document analysis), which is the strength of a case study design (Baxter & Jack, 2008, p.544), allowed data from interviews and document analysis to be converged during analysis. This ensured credibility of findings. In addition, qualitative methodology allowed the researcher to document participants’ perceptions showing different aspects of the PGDE programme.

**Population and sample**

In this study the population comprised pre-service science teachers in the PGDE programme at the ZOU Regional Centre P. Twelve PGDE pre-service science teachers were purposively sampled, based on their usefulness to the study according to the researcher’s judgment. The teachers taught at different schools in the Region, so they were conveniently sampled based on their proximity to the workplace of the researcher in order to cut on travelling expenses and time needed to visit members of the sample during data generation and collection.

**Research instruments**

The instruments used in data generation were a semi-structured interview guide and a document analysis guide. The interview guide comprised sections A and B. Section A had questions concerning to do with subject taught and teaching experience. Section B sought to solicit data on perceptions of pre-service science teachers on how the ZOU PGDE prepared them to teach science. The document analysis guide focused on areas which helped the researcher to consider particular issues like the intended educational objectives of each document. The document analysis guide sought to compare the PGDE Course Outline and PGDE Modules with the secondary school science curriculum and S&T policy documents. Both instruments were self constructed and validated by two colleagues who are researchers.

**Data generation**

Interviews were conducted with 12 pre-service science teachers in various secondary schools surrounding the workplace of the researcher. The interviews were one-on-one and took 40 to 60 minutes each. They
were done at the school of each interviewee in a place offered as convenient by the interviewee. For ethical reasons, interviewee consent was sought before interviews, and the interviewees were assured of their anonymity for confidentiality. The semi-structured interviews allowed interviewees to give their views freely, while at the same time keeping the interviews focused on issues of concern to the study.

Document analysis involved the comparison of the PGDE course outline and modules with the first Science and Technology Policy of Zimbabwe, the second Science, Technology and Innovation Policy (STI) of Zimbabwe, professional teacher standards for Zimbabwe, A-level Physics, Chemistry and Biology syllabi, O-level Integrated Science, O-level Physical Science and O-level Biology syllabi. The purpose was to establish areas of congruence, and/or convergence and divergence, between the ZOU PGDE curriculum documents and the secondary school science syllabus and S&T policy documents which specify the competences science teachers should have in order to teach effectively.

Data analysis

The data analysis procedure used in this study was thematic analysis. This involved coding of data in interview transcripts. At a practical level, the procedure involved the use of highlighter pens of different colours, circling or underlining key words and phrases, or the listing of codes in the margins while reading through the transcripts. The margins of the transcripts were also used in noting questions, interpretations and insights. The information was documented on a computer according to a process called charting (Kaucker, Paterson & Krupa, 2012; Statistical Services Centre, 2000, p.3). Charting involves boxing data according to categories containing words and paraphrases of key issues as well as snippets of data. The copy and paste function of the word processor enabled the researcher to move data into emerging categories easily. Categories were developed corresponding closely to the context as reflected by the actual words of interviewee responses. As part of the analysis, similarities and differences about compiled codes were clustered to create categories. From this, themes under which findings were presented were developed. Data obtained from various documents were compared to establish areas of convergence and divergence, which constitute the findings of the study.

Delimitations

The study’s focus was on pre-service science teachers’ perceptions of science teacher preparation through Open and Distance Learning. The study was done with 12 pre-service science teachers at Regional Centre P, whose schools were conveniently near the workplace of the researcher.

Findings

The findings were analysed to reveal the following categories (codes):
1. The Focus of the ZOU PGDE programme
2. ZOU PGDE Assumptions
3. ZOU – School Partnership
4. Challenges of Mentoring in the PGDE Programme
5. Awareness of Science Teacher Roles
6. Large Classes and Shortage of Resources
7. Laboratory and/or practical work preparation
8. Strengths of the ZOU PGDE programme
9. Weaknesses of the ZOU PGDE programme

An overview of the documents that were analysed is given below and subsequently followed by interpretation of data.

The O’Level Physical Science and Biology syllabi prepare pupils for studies in physics, chemistry and biology beyond ‘O-
level, as well as being a worthwhile qualification for those not proceeding with study beyond this level. The syllabi put more emphasis on the understanding and application of scientific concepts, principles and skills (ZIMSEC, 2008, p.2; 2011, p.3; 2013, p.2). Teaching and learning strategies which should be used are practical and investigative in nature. Applications of science and technology to agricultural, environmental, social and economic issues are included to extend subject concepts and skills. The A–Level Physics, Chemistry and Biology syllabi focus on preparing learners to pursue science in various fields like medicine, electrical engineering and mining. The implication is that newly qualified science teachers should have SPCK to effectively teach these subjects. However, development of SPCK by the PGDE was found by the current study to be weak. This negatively affects the quality of science education in schools, because teachers will be deficient in competences needed to teach effectively.

Teacher professional standards

Another document that was analysed is Zimbabwe’s Teacher Professional Standards (TPS). The document was developed by the Ministry of Primary and Secondary Education (MoPSE) to guide teaching and learning in primary and secondary schools in Zimbabwe. In the TPS, expectations about the performance of teachers and general practical examples are given. For instance, for the sub-domain Curriculum, the standard is:

*The teachers demonstrate full understanding of the syllabus they are expected to teach.*

The example of the descriptor for this standard is:

‘Class appropriate, relevant content, ability to match learning objectives, content, methods, materials, and assessment. What is covered in teaching and learning is reflectivity of local community’ (MoPSE, 2015, p.2).

From the above example, it is clear that the TPS are general, implying that they apply to all teachers irrespective of subject specialisation. This implies that science teachers should adapt the standards to their subject areas. This calls for science subject specific skills called “science pedagogical content knowledge” (SPCK), which the PGDE programme should develop. Unfortunately, the study showed that the ZOU PGDE programme does not develop the subject specific skills science teachers require. In this regard, implications to teaching and learning of assumptions unwittingly or unwittingly made by ZOU are discussed in the next section.

Need for SPCK in the PGDE

Student teachers with non-science teaching degrees like BSc and BSC Hons have enough science content to meet the demands of secondary science teaching up to A-Level. The PGDE’s mode of preparation leaves it to the pre-service science teachers to link science content (physics, biology, chemistry, physical science) with various general teaching and learning strategies called pedagogical knowledge (PK) in order to develop SPCK. The question to ask is: “To what extent are pre-service science teachers capable of developing SPCK?” Analysis of current research findings shows that this assumption is at variance with what pre-service science teachers can do in the development of SPCK. Research shows that science pre-service teachers need assistance to learn how to teach effectively. In support of this, Davis (2005, p.345) observes that pre-service teachers need support during both planning and teaching when adapting curriculum materials, so that they are appropriate to their students, contexts, objectives and preferred learning styles of
students. Therefore, pre-service teachers need to be supported in developing beginning levels of proficiency in these demands of teaching and learning. While all other documents concur (science syllabi and TPS) regarding the SPCK that teachers should apply, the PGDE programme appears not to put much focus on assisting science subject specialist pre-service teachers (Physics, Chemistry or Biology) to develop relevant SPCK. This was identified as a threat to the assumptions made about the potential of ZOU science student teachers with regards to their ability to develop SPCK for effective science teaching and learning, and to develop STI skills in learners.

The focus of ZOU PGDE programme

The ZOU Faculty of Arts and Education Department of Teacher Development Regulations for the PGDE (Revised) (ZOU, 2016) state that intended learning outcomes should produce:

1. An effective reflective classroom practitioner with good management skills;
2. A practitioner who is able to carry out action research and other forms of research independently;
3. A practitioner conversant with teaching methodologies and other emerging issues;
4. A self evident and proactive practitioner with the ability to empathise counsel and relate approximately with secondary school pupils; and
5. A practitioner with a strong theoretical educational foundation who is able to marry theory with practice with and outside the school environment.

According to the ZOU (2016) regulations, the PGDE content areas are Psychological, Philosophical and Sociological Perspectives in Education, Educational Management, Gender Issues, Research Methods and Science Curriculum Issues.

The PGDE programme covers the general professional development aspects of science teachers, but it has no SPCK, say in Chemistry, Biology, Physics, Physical Science and Integrated Science, which are specific science subjects in the science education curriculum of Zimbabwe. The programme falls short of preparing teachers to fully use the approaches which are indicated in the various Zimbabwe secondary schools science syllabi and Zimbabwe TPS. The National Council for Teacher Education (NCTE) (2009) observes that teacher quality is a function of many factors like teacher status, remuneration, conditions of work, teachers’ academic and professional education, among others. A review of the programme is necessary to enable the programme to meet the specific needs of the science subject specialist teachers.

ZOU-School partnership

Pre-service teacher preparation is no longer a total responsibility of teacher education institutions, but a collaborative partnership among various stakeholders. The establishment of these collaborative partnerships is not a spontaneous process without structures, but is purposefully initiated and well organised. At the very onset, collaborative partnerships provide environments effective for learning by student teachers (Valencia, Martin, Place, & Grossman, 2009, p.2). Consistent with this perspective, student teacher X said:

*Mentors play an important role to refocus on what teaching is about. When I started working straight from university I thought I knew what teaching was all about, but now through mentorship I see that there is a lot I did not know. I have also realised that learning to teach effectively is a continuous process. A mentor is an experienced guide who gives direction to the teacher on training.*
This comment points to the important role mentors play in pre-service teacher preparation.

Attachment teaching practice (ATP) is critical to pre-service teacher training, since it initiates the novice entrant to the teaching profession. Therefore, mentors should have SPCK to ensure that pre-service science teachers develop the relevant competences during ATP. In line with this view, pre-service science teacher T said:

*One challenge in the PGDE programme is the lack of subject specialised mentors like in Chemistry or Physics. For instance a Physics mentor cannot assist a Biology student teacher in conducting successful A-Level Biology practicals.*

Therefore, lack of subject specialist mentors adversely affects the development of SPCK. Interviewee P, who was a mentor, said:

*Schools select who becomes a mentor based on teaching experience regardless whether one understands subject mentorship roles or not.*

This is corroborated by Mtetwa, Chipangura, Kwari & Makamure (2002, p.291) who say that anyone with sufficient work experience has a potential to be a mentor. However, experience and expertise alone cannot change a badly experienced teacher into an effective mentor. There is need for structured science subject specific educational guidelines offered by ZOU to mentors which give direction on what mentors need to know and do in science teacher training.

Many school–university collaborative partnerships have demonstrated problems related to organising and monitoring teaching practice (Kecik & Aydin, 2011, p.73). Most collaborative partnerships have been criticised for failing to establish an equal relationship between school teachers (practitioners) and university or college supervisors (academics) (Valencia, Martin, Place, Grossman, 2009, p.5). This study revealed that there were no clear guidelines which the student teacher could use on the nature of the mentorship. Mentors in the ZOU PGDE programme were not sure of the extent to which they should go in assisting the science student teacher to develop SPCK due to lack of terms of reference. Therefore, the mentorship reflected the characteristics of a loose partnership. In this vein, ZOU should provide clear guidelines which enable mentors to work efficiently in assisting science pre-service teachers to develop SPCK (Tobin in Fraser & Walberg, 1995), which are consistent with national views on science like the current views on science, technology, engineering and mathematics (STEM) propounded by the Ministry of Higher and Tertiary Education, Science and Technology Development (MHTESTD) of Zimbabwe.

Research studies have shown that loose partnerships adversely affect teacher education programme implementation. Valencia, Martin, Place & Grossman (2009) identify disorganisation as a problem in teacher education due to lack of preparation and support needed in guiding student teachers. Zeichnner (2010, p.95) argues that an equal and more dialectical relationship between the academic and the practitioner is necessary for building bridges between universities and schools. Only such a relationship can enable the school teacher (mentor) to help the student teacher in linking theory learnt at university or college with practice.

**Challenges of Mentoring in the PGDE Programme**

Two challenges interviewees revealed to be predominant were a mentor–mentee paradox and lack of subject mentors. A paradoxical relationship that was identified by the study is the case of a PGDE student who taught
for more than ten years as a temporary teacher at school Q. By virtue of experience at school Q (10 years), the PGDE pre-service science teacher has been a mentor to a qualified teacher M who joined school Q five years ago. When the temporary teacher became a ZOU PGDE student teacher a year ago, the qualified teacher M who joined school Q five years ago became the student teacher’s mentor. In this case, the mentor could have difficulty in mentoring meaningfully.

When the qualified teacher was asked about handling such a situation the response was:

_I usually present what I feel needs to be adjusted by the student teacher who has been my senior by making suggestions or consulting, so that we share ideas. Fortunately this teacher is cooperative. It could have been difficult if my mentee had feelings that I should not be mentoring._

The response by teacher M shows that skills in using appropriate mentoring approaches in managing such situations are needed. All the 12 pre-service teachers who were interviewed concurred that there were many such cases in the ZOU PGDE programme.

Pre-service science teacher U said:

_There is a shortage of science teachers in many schools, so it’s common that qualified science subject teachers are not there in schools. This makes it a challenge for mentees to get appropriate subject specific mentors._

Pre-service science teacher R said:

_Some of the young science teachers graduating from universities with science teaching degrees are expected to mentor pre-service science teachers who have been in the field as temporary teachers for many years. This is a challenging task to the young teachers which may compromise the quality of mentoring, hence poor pre-service preparation._

The two quotations show that there is lack of appropriate mentors in the schools in which some of the ZOU PGDE pre-service science teachers do their attachment teaching practice (ATP). This is an issue of great concern because ATP is critical to pre-service training, since it initiates the novice entrants to the teaching profession.

Another challenge was the lack of subject mentors. For instance a Physics specialist was found mentoring a Chemistry PGDE student teacher. The implication is that the mentor assisted the mentee in the general science teaching methodology and SPCK for lower levels up to O-Level. However, the mentor was said to be not helpful in developing SPCK A-Level Chemistry content for the student teacher. As in the case above, all the 12 pre-service teachers interviewed concurred that they were many such cases in the ZOU PGDE programme.

A possible solution to the challenges discussed above could be the choice by a PGDE student teacher in such a situation of another school where the subject is offered at A-Level, so that the mentor is a subject specialist and has no “umbilical” connection to the student teacher. However, such an arrangement has cost implications since another teacher will need to take the post left by the ZOU PGDE student teacher on ATP. This may not currently get support from the government because reducing the salary portion of the budget is one of the cost cutting measures being implemented to improve economic performance. As for now the situation may remain as is.

The foregoing discussion has revealed how challenges adversely affect the preparation of pre-service science teachers in the PGDE programme. It is necessary to find ways of improving areas of concern identified, so that ZOU PGDE pre-service science teachers are appropriately prepared.
Awareness of science teacher roles

One science student teacher (“N”) was asked what the most important roles of the science teacher were. The response was “preparing students to be able to pass with the highest grades”. Asked how this related to national goals, the teacher said that this would enable most if not all of the students get university places in addition to giving a good reputation to the school and the teacher through high pass rates. There was no mention of development of S&T skills or making secondary school graduates STEM compliant, as advocated by the government through radio, TV, print media, curricula documents, MoPSE and MHTESTD. Therefore, there is need to address this issue in the programme by producing PGDE graduates who are STEM compliant. Generally, student teachers should be assisted to understand how vital they are as agents of change who should support government policies.

Large classes and shortage of resources

The face to face contacts were found to be very few, which is consistent with the ZOU PGDE implementation of the ODL programme. However, all twelve science student teachers concurred that large classes of up to 60 students and lack of resources were common in secondary schools in Zimbabwe, and that there was no possibility of a reduction in class size in the near future. All the student teachers concurred that the PGDE programme should strive to equip them with skills to ameliorate the shortage of resources and manage learning in large classes. Use of student-centred participatory teaching and learning strategies in large classes was said to be challenging and required one to have a repertoire of skills.

This points to the need for student teachers to develop these skills during the PGDE preparation phase.

Laboratory/practical work preparation

Despite a convergence in belief on the assumptions of science teaching and learning based on notions of constructivism and reflective practice (Cakir, 2008 p202), sharp distinctions exist in the way science teachers are prepared. The ZOU PGDE programme was observed to concentrate on general professional teaching skills rather than focusing on SPCK. SPCK enables science teachers to adapt teaching to various teaching and learning contexts. With regards to practical work in science education, in the context which lack of apparatus and other learning aids, improvisation is an important way of mitigating shortage of apparatus (Mhishi; Bhukuvhani & Sana, 2012, p.80). However, absence of improvisation in the ZOU PGDE programme points to the need to review the programme with a view to improving its capacity to develop the requisite improvisation attributes expected of a science teacher in the Zimbabwean context.

Strengths of the ZOU PGDE programme

The strengths of the ZOU’s PGDE programme included:
1. Producing a large number of qualified science teachers at one time.
2. Low cost.
3. Convenient on job training.
4. Availability of Regional Centres.

Weakness of the ZOU PGDE programme

The ZOU PGDE has this weakness:

• Weak SPCK development

Conclusion

It can be concluded from the findings that ZOU is contributing greatly to the national
objective of increasing the number of science teachers. It was also noted that, while pre-service teachers had good subject content mastery, ‘the how to teach the subject content’ or science pedagogical content knowledge (SPCK) was weak. Therefore, more science pre-service preparation in SPCK is needed in order to produce desired learner outcomes in schools.

**Recommendations**

Four recommendations from the study were:

1. A framework for ZOU collaboration with schools to establish the exact expectations of science teachers should be developed;
2. Science teacher mentors should be recognised more by both ZOU and MoPSE, so that they are fully supported in developing the requisite science teacher attributes consistent with national science national goals like achievement of STI and STEM aims and objectives;
3. Improvisation in science teaching and learning should be included in the PGDE programme; and
4. Development of SPCK should be included as a pre-service science teacher intended learning outcome.

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