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The Training of a Science Teacher in an Open and Distance Learning Context: Student Teachers' Perception

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ABSTRACT The Report of the Task Team for the Review of the Implementation of the National Curriculum Statement shows that teachers are not well trained in respect of the subjects they are supposed to teach. Most of the teachers in South Africa are trained through open and distance learning (ODL) mode – learning is provided and organized around the geographical, social, and time constraints of the learner and teaching is conducted by someone removed in space or time from the learner. This article attempts to investigate the perceptions in-service student teachers have about a science module presented at one of the ODL institutions in the Postgraduate Certificate in Education (PGCE). Student teachers' perception about the focus the science module has on subject matter knowledge and pedagogical knowledge is investigated. A mixed method research design was utilised in this study. A quantitative phase was followed by a qualitative phase with the aim of articulating the convergence the two phases have towards capturing the same phenomenon. The study indicated that primary school science teachers' limited knowledge of science restricted them from effectively teaching content knowledge in natural science classes. In-service teachers also feel that the science module offered in an ODL mode does not adequately address the practical component of science teaching. The study suggests that ODL institutions should work towards providing science students with adequate pedagogical content knowledge which is critical in science teaching.

INTRODUCTION

The notion that teachers are not well trained in respect of the subjects they are supposed to teach has been highlighted by the Report of the Task Team for the Review of the Implementation of the National Curriculum Statement (DoE 2009: 10). This report reiterated the fact that there is paucity of appropriately trained science teachers and that most of them have not been sufficiently prepared with apposite methodologies and subject matter in science teaching. With this in mind, one can assume that the so-called low performance of learners in science (Dilotsothle et al. 2001: 305; Taylor Vinjevold 1999) is due to the inappropriate training student teachers receive at institutions of learning. Various international and national studies have been conducted about deficiencies that primary school teachers have with regard to the teaching of science. In Australia, as in the UK, primary school teachers with limited science knowledge could hardly use a textbook and relied mostly on internet searches of resources which they thought were appropriate for engaging learners in science activities (Appleton and Asoko 1996: 169-171; Osborne and Simon 1996: 99-147). Tobin and Garrett (1988: 205) argue that the lack of necessary content knowledge has a negative impact on the teaching of natural sciences.

In South Africa, for example, little has been done with regard to factors that influence the low performance of learners in science teaching at primary schools level (Fleisch 2008:12; Reddy 2005: 64-66). To better understand efforts that are put in place to enhance elementary teachers' knowledge for quality teacher education in South Africa, particular attention is given to the in-service perceptions of these efforts.

Problem Statement

Because the training of the majority of teachers is predominantly provided through an open and distance learning (ODL) mode in South Africa, it is necessary to identify the realities of science teachers who are trained through this mode. This article attempts to investigate the perceptions in-service student teachers have about a science module presented at one of the ODL institutions in the Postgraduate Certificate in Education (PGCE). This study is aimed at addressing the question: Is the science module offered in the PGCE programme at an ODL institution preparing teachers in terms of subject content knowledge and pedagogical knowledge? Suggestions and recommendations for better quality ODL university programmes for pre-service teachers in the primary schools are made.

Conceptual Framework

The conceptual framework for this research draws much from the work of Lee Shulman (1986, 1987) who made an in-depth study of different knowledge bases in terms of the teaching of science. Among the different knowledge bases that Shulman elaborated on, the subject matter knowledge (SMK), pedagogical knowledge (PK) and the pedagogical content knowledge (PCK) remained the precursor of what is essential to effective science teaching (Shulman 1987: 5-10). Shulman (1986: 13) draws our attention to the difference that may exist between SMK, PK and PCK. By subject matter knowledge, Shulman referred to the "amount and organisation of knowledge per se in the mind of the teacher" (Shulman 1986: 13). Zeidler (2002: 28) adds that SMK refers to "a teacher's quantity, quality and organization of information, conceptualizations and underlying constructs in their major area of study". PK, according to Shulman (1986: 9), means how the subject matter can be represented and formulated in such a way that it is understandable to others, that is, how the teacher uses the "analogies, illustrations, examples, explanations" and ideas in a lesson. PK also refers to a teacher's knowledge of basic instructional variables such as classroom management practices, questioning techniques and how to handle routines. Other knowledge bases included curriculum knowledge that explains the knowledge that the teacher should have, which may include textbooks and software knowledge; and laboratory demonstration skills. Ellis (1995:146-161) mentions that the teacher is also expected to have knowledge of educational ends, purposes and values; knowledge of educational contexts and knowledge of learners and their characteristics and knowledge of suitable ways of assessment and evaluation. Shulman has identified PCK as distinctive of teachers' practice and worthy of special attention and was therefore used in this study as an underlying construct to gain insight into the science background knowledge and teaching strategies that school teachers must have to be able to teach as expected (Shulman 1986: 43).

PCK can be defined as "that special amalgam of content and pedagogy that plays an important role in ensuring that teachers can form their own professional understanding" (Shulman 1987: 8). Zeidler (2002: 28) mentions that PCK represents "teachers' ability to convey the underlying details and constructs in their field of specialization in a manner that makes it accessible to their students". Veal and Makinster (1999:1) explain that science PCK is a new form of teacher knowledge transformed from, and embodying, the other forms of teacher knowledge. Pedagogical content knowledge is regarded as academic construct that represents specialist knowledge of practice (Appleton 2003: 10-15; 2006:31-54; Bradbury and Koballa 2007:817-820; Hashweh 2005: 273-337; Nillson 2008: 1281-1283). Van Driel et al. (1998: 673-695) contend that PCK is a way of understanding the complex relationship that exists between teaching and content by applying precise teaching approaches. Nillson and Van Driel (2010) argue that PCK goes beyond ordinary subject matter knowledge and also has the teaching of subject in ways that promote learners' understanding as a focal point.

Pedagogical content knowledge cannot only be confined to the interrelatedness between the subject matter and pedagogy. There are different forms of teacher knowledge that play a role in the development of science PCK, for example, knowledge of students, classroom management, assessment, curriculum context, environment, socio-culturalism and the nature of science (Appleton 2002: 394). Science knowledge is obviously derived from science content knowledge. Goodrum (2001) argue that most of the science teachers do not have a strong background in science subject matter knowledge as such. Appleton (2003) acknowledged that in most instances, primary school teachers have inadequate science subject matter knowledge, which in many instances results in low confidence with regard to science teaching. On the contrary, Zeidler (2002) warns that a teacher's subject matter knowledge may be a necessary but insufficient condition for the transfer of central ideas, precepts, tenets and underlying thematic concepts for a given discipline to be made accessible to his or her students. Good generic classroom management tools, like questioning techniques, will ensure that the core ideas (SMK) can be presented efficiently.

Teacher education institutions are faced with a huge challenge of ensuring that their programmes go beyond mere acquisition of subject matter knowledge, but also ensure that their programme promotes learner's understanding.

PCK, in which pedagogy and content are blended, is unique to teacher education. It enables the teacher to combine his/her understanding about a particular topic or theme with teaching strategies and additional knowledge to advance student learning in a practical situation. Attempts to communicate the link between practice and knowledge is a challenge, because, for many teachers their practical classroom situation and knowledge that tend to shape that practice are in most cases implied and understood (Schön 1983). The articulation of the link becomes even more complex in ODL institutions. Teacher education is a crucial area where open and distance education has been used widely to provide, among others, pre-service teacher preparation and upgrading of academic qualifications, and in-service continuing professional development in particular subjects, content areas and instructional methods.

RESEARCH DESIGN

A mixed method research design was utilised in this study. A quantitative phase was followed by a qualitative phase (Schulze 2003) with the aim of articulating the convergence the two phases have towards capturing the same phenomenon. The focus of the approach is placed on convergence and validity (Polit and Beck 2004:279).

Sampling

There are two basic teacher programmes offered at a selected ODL institution: The Post Graduate Certificate in Education certificate for in-service teachers and the Bachelor of Education programme for pre-service teachers. The purposive sampling was used in this study and the PGCE students enrolled for a science module were involved in the study. Two hundred and fifty- eight students registered for the science module took part in the study. The module deals with the methodology of teaching natural sciences in the intermediate and senior phases (grades 4-7) and in the FET phase. The science module elaborates on teaching strategies that can be used for teaching science, the assessment of learners, the purpose of teaching science, and classroom practices such as lesson management and preparation.

Data Collection

Questionnaire and interviews were used to collect data. A questionnaire was administered to 258 students to gain more information about the science module and how it impacts on their classroom practice. One hundred and twenty-three students (N=123) responded. The credibility of the questionnaire was sought by implementing member checking and peer review (McMillan and Schumacher 2006; Krefting 1991). The questionnaire comprised of four sections, namely the biographical information; knowledge teachers should have with regard to the teaching of science; what in-service teachers regard as essential components of science teaching; and whether the module equips teachers appropriately for the teaching of science in schools. Twenty-two closed and two open-ended questions were asked. These 22 questions were organised into a Likert-type scale, consisting essentially of statements or phrases, followed by a four-point rating scale indicating the participants' agreement with them. PGCE students who were thought to be rich in information were purposively chosen and interviewed (Cohen and Manion 1995: 89).

Data Analysis

The questionnaires were coded; statistics and percentages of responses for each questionnaire item were calculated (Gall et al. 2005: 157). Data was analysed using Statistical Package for Social Sciences (SPSS). The data was described and analysed to identify common themes that were merged with data from the questionnaires. Results from the questionnaires were tabulated and analysed using a rating score and rating scales respectively. The data from interviews was captured by an audiotape which was transcribed and categorised according to themes. Ethical requirements were met and all participants gave written consent for the digital recording of interviews. Data were also analysed using quotes or raw data from the questionnaire.

RESULTS AND DISCUSSION

Data collected from questionnaires and interviews reveal a number of perceptions in-service teachers have about science teaching in an ODL context.

Biographical Information

As most of the respondents were already in teaching post at schools, they had to indicate the phase they teach in. The data for this is presented in Table 1.

Table 1: **Student teachers' teaching phases**

Registration of students according to programmes	*N=123*	*Percentage*
PGCE (Intermediate and Senior Phase)	120	97.6%
PGCE (Senior and FET Phases)	3	2.4%
Total	123	100%

Table 1 shows that most of the student teachers (97.6%) enrolled for the science module were in the PGCE (the Intermediate and Senior Phases) programme and these were teachers at elementary level. 2.4% are in the Senior and Further Education and Training phases. Furthermore, the majority (67%) of these student teachers were permanently employed with the Department of Education and 57% of them were young female teachers between the ages 19 and 39. Most of these teachers have basic teachers' qualification (three year teachers' diploma) as they have been in the employ of the DoE for a long period and occupy permanent posts.

Focus of the Module on Subject Matter Knowledge

In response to questions that were posed to the respondents about their perception on the inclusion of subject matter knowledge in the science module, student teachers raised serious concerns about this aspect.

Seventy-seven percent (77%) of respondents emphasize building science subject matter as the most important goal to prepare teachers for primary school teaching (Table 2). Respondents feel that the subject matter knowledge that they have acquired was not enough and therefore needed advanced knowledge on physical sciences and chemistry. One respondent stated:

More content on different science topics and how to develop lesson plans on different topics must be included in the science module.

Another respondent continued to say:

More content should be included in the teaching of the science module...It should be noted also that some teachers who teach science are not good in science and this impacts on the students and hence content should be included.

Table 2: **Inclusion of subject matter knowledge and pedagogical knowledge in the science module**

	Agree (N=123)		*Disagree (N=123)*	
	N	*%*	*N*	*%*
Science module should focus on subject matter knowledge	95	77%	28	23%
Science module should focus on methodology	56	46%	67	56%
Science module should focus on subject matter knowledge and methodology	112	91%	11	9%

Lack of subject matter knowledge by school teachers will have a negative impact on classroom practice. Abell and Roth (1992:592-593) agree that primary school science teachers' limited knowledge of science restricted them from effectively teaching content knowledge in natural sciences. A well-known and common argument is that science teachers need to 'know more science' in order to be 'better' natural science teachers (Kind 2009:169). Kind (2009:169-204) further argues that being academically well qualified in a subject, or being in possession of a good Bachelor's degree in a science subject, for example, doesn't necessarily provide a guarantee that someone will teach a science subject effectively.

Focus of the Module on Pedagogical Knowledge

Less than half (46%) of the respondents agree that the module should focus on pedagogical knowledge only. In response to how student teachers rated themselves on the knowledge they have about pedagogical knowledge such as teaching strategies dealt with in the science module, their response was as seen in Table 3:

According to Table 3, student teachers rate themselves high (70%) with regard to their understanding of teaching strategies, except for the inquiring learning strategy where about 50% of them feel their understanding falls between moderate and low. Inquiry learning which is linked to investigative and critical learning needs attention. In-service teachers are of the opinion that much needs to be said about inquiry learning in the module. One respondent stated:

Table 3: Student teachers' understanding of teaching strategies

	High (N=123)		*Moderate (N=123)*		*Low (N=123)*	
	N	*%*	*N*	*%*	*N*	*%*
What is your level of understanding of inquiry learning?	64	52%	25	20%	34	28%
What is your level of understanding of cooperative learning?	99	80%	19	16%	5	5%
What is your level of understanding of science teaching strategies in general?	81	70%	31	25%	6	5%

I am new at this (teaching science) and need to find the balance between getting through the work and guiding the learners to discover the work and that there is more to science than a bunch of facts that they need to know.

Most teachers (80%) are confident about the degree of conceptualisation of cooperative learning as a teaching strategy.

Focus of the Module on Generic Instructional Variables

Pedagogical knowledge also refers to a teacher's knowledge of generic instructional variables such as classroom management, curriculum knowledge which explains the knowledge that the teacher has which may include textbooks, software and laboratory demonstration skills, knowledge of educational contexts and knowledge of learners and their characteristics (Shulman 1987). The respondents had to indicate how the module contributes towards these generic classroom practices. The responses are indicated in Table 4.

The survey data shows that the majority of student teachers (80%) enrolled for the science module have the perception that it is relevant and links with topics/themes prescribed by the DoE. 86% of respondents feel that the module makes them feel confident in approaching science topics in their respective phases. However, respondents feel that the module does not adequately address the practical component of science teaching. About 8% of the respondents feel that even though different teaching strategies are dealt with in the module, they still need to see their practical implementation. One respondent stated:

I feel that there should be more practical work for learners to learn hands-on laboratory skills and that perhaps there should be a small section that deals with these skills in the module. I want to see more on how to demonstrate experiments with maybe some examples of experiments for each area of knowledge.

Table 4: Contribution of the module towards classroom practice

	Agree (N=123)		*Disagree (N=123)*	
	N	*%*	*N*	*%*
The science module equips me to work within science topics.	98	80%	25	20%
The current science module helps me to teach different types of school science content areas.	98	80%	25	20%
Content in the science module makes me feel confident in teaching science.	106	86%	17	12%
Science teaching strategies are practically dealt with in the module.	10	8%	113	92%
Science teaching strategies in the science module are comprehensively dealt with in the module.	92	75%	31	25%
Science module should focus on practical ways of teaching science.	84	68%	39	32%
The current science module has a "hands-on" approach as its focus.	49	40%	74	60%
The current science module enhances my skills on how to perform experiments.	60	49%	63	51%

This goes further to call for course designers to also address the issue of practical work, for example, how to perform an experiment for learners. Student teachers agree that the theory and exposition of course material is at a high level, but that attention should be given to the way in which the contents of the learning material should be implemented. Only 50% of the respondents mentioned that the module enhances their practical skills on how to perform experiments. The PGCE students want the science module to guide them in practical terms on how to engage learners both mentally (minds-on) and physically (hands-on) with what they are doing in the science class. Respondents emphasize the importance of observing how theory is put into practice. This challenge be-

comes complicated for ODL institutions as teaching and learning are realized outside educational institutions. The challenge of linking theory with practice becomes even more complex for students predominantly located in rural areas studying at ODL institutions. These students are positive about teaching science in rural areas, but they feel that the science module should address issues around the improvisation of science apparatus. The module could also deal with home-made apparatus that can replace laboratory apparatus such as measuring cylinders, conical flasks and balance scales.

Other general curricular variables such as elements of lesson plans were raised by respondents as forming the integral part of the science module and therefore needed to be dealt with adequately. One respondent mentions that "more examples of lesson plans" should be included in the science module. Another respondent states that "the science module should focus on building subject framework, work schedule and lesson planning". The link between subject matter and teaching methodologies should vibrantly and adequately be addressed. Berliner (1988) agrees that effective teaching will be demonstrated through a teacher's comprehension of, and reaction to, the connection between subject matter, pedagogy and learning in ways that prove to notions of teaching practice as being intricate and multifaceted.

CONCLUSION

It has been established in this article that the science module should focus on SMK and PK. The challenge facing ODL institutions is to ensure that subject matter knowledge is well-integrated with pedagogical knowledge. This calls for colleges or universities offering in-service and pre-service teachers' science programmes to find common grounds on how to integrate and blend the two knowledge bases in their science programmes. The challenge is enormous for ODL institutions as they are offering science through distance learning. ODL institutions fail in providing some of the generic classroom practices which may result in producing not so competent science teachers.

RECOMMENDATIONS

Since distance education involves the absence of face-to-face contact entrenched in conventional education, this poses a serious challenge to the teaching of practical sections of the science module. There is a serious need for interaction. Media with high interactivity can be used to communicate with students. There is a range of communication and technological devices available to deliver distance education programmes in ODL institutions. ODL institutions should adopt a "media mix", namely, interactive and non-interactive media, electronic media, and printed materials. These include using computer-based instruction, World Wide Web (web) applications, CD-ROM, electronic mail (e-mail), video-conferencing, computer conferencing, DVDs. The combination of these communication and technology devices will ensure that the delivery of distance education becomes effective and efficient. Of course, one of the challenges facing ODL institutions is to cater for students who are located in the deep rural areas, who are unable to access these new technologies. Text-messaging, face book and cell phone devices can also be used to interact with students in the rural contexts. One should quickly point out that students are social beings, and therefore no technology, can function as an ideal substitute for human interaction. Students would generally prefer more face-to-face contact and formal lectures. It seems that the possible solution in providing answers to most ODL challenges is the use of technology. Technology must be able to demonstrate different phases of scientific investigation to be implemented in the classroom to students. Student teachers call for ODL institutions to ensure that the subject matter knowledge and the pedagogical knowledge form a harmonious whole so that it can effectively equip teachers with relevant science skills.

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