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An Investigation into the Effectiveness of the University Curriculum in Preparing Pre-service Technology Teachers

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Abstract

The purpose of this study is to investigate the effectiveness of the university curriculum in preparing pre-service technology teachers. The study examines the course guide of the technology education course at one of the universities of technology in South Africa in relation to grades 7–9 (senior phase) of the technology policy document. The study found that the university technology curriculum places emphasis on both content breadth (CB) and content strands (CS). However, some of the CSs in the university technology curriculum have no relevance to the CB and were not designed to enhance its depth. Therefore, this means that the CSs of the university technology curriculum were not designed to focus on the notion of 'fitness-for-purpose' which is market driven. However, it is imperative that students be given an opportunity to explore both CB and content depth (CD) as well as how other CSs can be used to develop a deeper understanding of CB.

Résumé

Le but de cette étude est d'examiner l'efficacité du programme universitaire de formation initiale des professeurs de technologie. Il s'agit d'un examen du guide pédagogique de technologie utilisé dans une des universités de technologie en Afrique du Sud, notamment par rapport aux années 7-9 (cycle supérieur) du document de politique technologique. L'étude a révélé que le programme d'enseignement de la technologie à

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l'université met l'accent sur l'étendue du contenu (CB) et les thèmes du contenu (CS). Cependant, certains thèmes du contenu (CS) du programme d'enseignement de la technologie à l'université ne sont pas pertinents par rapport à l'étendue du contenu (CB) et ne sont pas non plus conçus pour améliorer sa profondeur. Par conséquent, cela signifie que les thèmes du contenu (CS) dudit programme ne sont pas conçus pour se focaliser sur la notion de l'«aptitude aux fins recherchées», qui est axée sur le marché. Toutefois, il est impératif que les étudiants aient l'opportunité d'explorer à la fois l'étendue du contenu (CB) et la profondeur du contenu (CD) ainsi que la façon dont d'autres thèmes du contenu (CS) peuvent être utilisés pour une meilleure compréhension de l'étendue du contenu (CB).

Introduction

The technology teacher training programme plays a vital role in African countries, especially in the aspect of educational reform. The new South African curriculum and that in other countries like Nigeria (Aguele and Agwagah 2007) have acknowledged the need to produce engineers, technicians and artisans to develop a technologically literate society for the modern world. In 1998, technology education was introduced for the first time in the South African curriculum as a learning area. The main purpose of teaching technology education in South African schools is to produce learners who are technologically literate and to provide them with an opportunity to 'develop and apply specific design skills to solve technological problems; understand the concepts and knowledge used in technology education and use them responsibly and purposefully; and appreciate the interaction between people's values and attitudes, technology, society and the environment' (Department of Basic Education (DBE) 2010: 13). However, a challenging issue was that the majority of teachers who were teaching technology had not been trained in this field because it was a new learning area. The fact that the teacher training curriculum at university did not include technology exacerbated the problem.

In early 2000, most universities introduced a technology course in their teacher training programme in order to address the challenge faced by schools. The teacher training programme at university level usually has two components, content knowledge (CK) and pedagogical training. However, universities differ in their approach to training. For example, in some universities students first participate in a specific programme that focuses on CK education and only during their final year of study do they enrol for the fundamental education courses; in other universities, the two programmes run concurrently with a focus on both CK and fundamental education courses. In the university where this study was conducted the programmes are presented concurrently in the education department. However, the extent to which CK prepares technology teachers to teach school content knowledge should be explored.

In accordance with this point of view, UNESCO (2002: 8) has indicated that teacher training should improve student teachers' educational background; increase their CK; develop pedagogical knowledge of their subject; increase learners' knowledge within the relevant context; and develop practical skills and competencies. Therefore, teacher training programmes in South African universities are not exempt from these objectives as practical courses are included in their teacher training programmes. In support of this view, Waghid (2002) conducted a study to examine whether the emergent shift in knowledge production can transform higher education in South Africa to the extent that it becomes more socially relevant. The study found that the knowledge produced at a university does not integrate with the needs of the community in which a student may practise on completion of a degree. This was the situation in the past and it is not likely to have changed.

Hence, this study sheds some light on the following questions, especially in relation to the technology education programme, and proposes that its findings could be applied to other fields. Firstly, should pre-service teachers obtain CK that emphasises only the CS (Kahan, Cooper and Bethea 2003)? In this context, CS refers to any subject domain concept found in any field of study. Secondly, should they obtain subject content knowledge (SCK) that covers the CB that is relevant to the level at which they will be teaching (Heritage 2007)? Lastly, should the curriculum address the SCK that is relevant and then move forward to deeper concepts (Doerr 2007)? The answers to these questions have potential consequences in technology teacher preparation programmes, especially given the growing emphasis on the need for teachers to gain a deeper understanding of the subject matter relevant to their chosen field of expertise (Hirsch 2001).

Research Questions

In this study, our interest focused on the following research questions:

- To what extent does the university curriculum cover the CB of the school curriculum?
- To what extent does the university curriculum cover the CD of the school content breadth concepts?
- To what extent do university curriculum CSs enhance school CB?

Effective Content Knowledge

Teacher training programmes have experienced difficulties in selecting the CK essential for teaching (Ball, Thames and Phelps 2008). This is not an exceptional case for technology education courses as a developing field of learning in the education sector. Peters (1977: 151) argues that if a programme is regarded as a specific preparation for teaching, priority must be given to a thorough grounding in its basic content. It is noteworthy that most teacher training programmes in all public universities were designed on the assumption that they would be based on the National Policy Framework for Teacher Education and Development (2007) as well as on the requirements of the Norms and Standards for Educators (2000). In practice, current training programmes are based on the Minimum Requirements for Teacher Education Qualifications (2011) which were developed from the National Policy Framework for Teacher Education and Development (2007) and the Norms and Standards for Educators (2000). These policies are provided to guide those who develop education programmes in a higher education institution (HEI).

Firstly, these policy documents stipulate that the primary purpose of a Bachelor of Education degree (BEd) is to provide graduates who are well equipped with the required SCK skills to teach this particular specialization. Secondly, teacher training programmes in the higher education system should aim to produce the kinds of teachers that the country needs. Lastly, the policy indicates that a competent teacher should possess the following attributes: specialism in a particular learning area, subject or phase; specialism in teaching and learning; specialism in assessment; be a curriculum developer, leader, administrator and manager; be a scholar and lifelong learner, and a professional who plays a significant role in a community. Hence, this study argues that the technology teacher training programme should provide graduates who have mastered school CK as minimum knowledge and are equipped to teach it effectively.

To explore how teacher training programmes can prepare pre-service teachers, the South African Department of Education (DBE 2010: 10) has provided a guideline and indicated in the national curriculum statement that it

> [ext] aims to produce learners that are able to identify and solve problems and make decisions using critical and creative thinking; work effectively as individuals and with others as members of a team; organize and manage themselves and their activities responsibly and effectively; collect, analyse, organize and critically evaluate information; communicate effectively using visual, symbolic and/or language skills in various modes; use science and technology effectively and critically showing

> responsibility towards the environment and the health of others; and demonstrate an understanding of the world as a set of related systems by recognizing that problem-solving contexts do not exist in isolation. [ends]
> Consequently, teacher training programmes should strive to produce teachers with such competences in order to be effective.

In response to these key competences, most of the literature makes intensive investigation into measuring teachers' pedagogical content knowledge (PCK) during pre-service preparation and in-service training. According to Shulman (1987), PCK is an amalgamation of CK and PCK. For instance, Ball, Thames and Phelps (2008) conducted a study to 'investigate the nature of professionally-oriented subject matter knowledge in mathematics by studying actual mathematics teaching and identifying mathematical knowledge for teaching based on analyses of the mathematical problems that arise'. They argue that teachers need to be conversant with all mathematical topics in the curriculum that they must teach, as well as acquiring a deeper knowledge above that required at school level. As a result of their investigation, these authors identify four domains that reflect competent teaching relative to comprehensive knowledge of the relevant subject matter.

The first domain, common content knowledge (CCK), is defined as the mathematical knowledge and skill used in any profession, including teaching. The second domain, specialized content knowledge (SCK), is defined as subject content knowledge and skill that is unique to teaching a particular subject. The third domain, knowledge of content and students (KCS), is the knowledge that combines knowing about students and their knowledge of mathematics. The last domain, knowledge of content and teaching (KCT), combines knowing about teaching and knowing about mathematics. In similar vein, Marshall and Sorto (2012) conducted a study analysing the effects of teacher mathematical knowledge on student achievement. The study found that teachers have different kinds of mathematical knowledge, for example, CCK andSCK. Pitjeng (2014) observed novice graduate science teachers' CK and topic specialized pedagogical content knowledge (TSPCK). Such literature attempted to describe how pre-service teachers' knowledge should be structured in a particular programme. However, issues concerning the specific type or scope of CK, as well as the breadth and depth that pre-service teachers should receive during a teacher training programme remain imprecise.

Seeking Breadth, Depth and Strands

What are the distinctive CB and CSs that should be expected of BEd graduates in South African university programmes? Given the diversity of their educational backgrounds, the possible uncertainty regarding their teachers' experience and the variety of school contexts and environments in which they have been taught, the argument is that BEd programmes in universities should focus on helping students acquire two core competencies, CB and CD. This proposal supports Freedman's (2008) notion that university programmes should be designed as being 'fit-for-purpose' i.e. be more market driven than previous approaches.

The term CB refers to the need for exposure to a wide variety of topics in the scientific disciplines (Schwartz et al. 2008). Li, Klahr and Siler (2006) indicate that CB refers to the scope or number of topics covered whereas CD refers to the deeper coverage of fundamental concepts that are beneficial to master (Schwartz et al. 2008). Teaching to develop deeper understanding upholds the view that certain fundamental concepts need to be taught and given greater attention. Students who have a deeper understanding of fewer scientific concepts in high school have actually shown greater success in college science coursework (Schwartz et al. 2008). Hirsch (2001) suggests that the best way to learn a subject is to move from broader knowledge, which is breadth, to deeper knowledge.

Murtagh (2001) argues that balance between breadth and depth of the content is more productive than a focus on either extreme. In addition, Wright (2000) also advocates that a balanced approach is more effective because it will maintain the enthusiasm of students. According to Irwin (2011), breadth refers to the variety of experiences, content and materials, whereas depth is about the intensity that accompanies understanding a set of ideas in a profound way and also the mastery of a body of knowledge. Hirsch (2001) argues that learning to learn and gaining deeper understanding depend on broad knowledge, but not just any knowledge will suffice. Hirsch identifies four principles as a guideline for choosing content. This author firstly indicates that the ability to learn something new is not primarily a general or formal skill but chiefly a domain-specific skill which depends on the relevant knowledge that already possessed by the learner about that specific subject. Secondly, the general ability to learn a specific subject is closely correlated with general knowledge. Thirdly, the best way to learn a subject is to grasp its general principles and to study numerous, diverse examples that illustrate those principles. Lastly, the ability to start from a broader, general knowledge and then progress to deeper knowledge provides the best approach.

CSs are the 'big ideas' that provide a variety of teaching strategies and activities to help teachers develop their students' understanding of concepts (Kajander and Holm 2013). According to the National Council of Teacher of Mathematics (NCTM) Standards document (1989), CSs are topics that appear to be separate and distinct but which are woven together intricately to develop student understanding. In this context, CSs are all topics in the university curriculum but not in the school curriculum; they are used to enhance students' deeper understanding of concepts learned at school.

Therefore, this study explores the type(s) of content knowledge on which a university focuses. In other words, does the university curriculum put emphasis on CB (specific subject content knowledge) that is relevant to the level at which the pre-service teacher will be teaching, or on CSs (any technology subject domain concepts), or should the university address both CB and CSs in order to increase deeper understanding of the concepts? In this paper, CB refers to the CK at the school-level that pre-service teachers will be teaching on completion of their degree. CD refers to the various concepts that cultivate an understanding of CB. CS refers to concepts that are technological in nature but develop CD, although they are not relevant to the CB.

Methodology

This exploratory study employed a qualitative research approach (Creswell 2013). The data was collected via document analysis of the university technology education curriculum and school technology content. Document analysis is a systematic procedure that can be used to examine and interpret data in order to elicit meaning, gain understanding and develop empirical knowledge (Bowen 2009). The school policy document, as well as study guides, were analysed to envisage the gap between the two sets of documents. For the analysis, the researcher used the policy document for Technology (Curriculum Assessment Policy Statement (CAPS) 2013) of the Department of Basic Education to develop the checklist which then served as a minimum benchmark for the CK that students must acquire before they graduate. In order to explore the CK coverage of the university curriculum in relation to the school curriculum, this study scrutinized the topics based on the qualitative content analysis method (Elo and Kyngäs 2008; Graneheim and Lundman 2004). Graneheim and Lundman (2004) describe qualitative content analysis as a method that focuses on the subject and context, emphasising the differences between them and their similarities within codes and categories. They further indicate that in this method, categories are groups of content that share a commonality.

Findings and Discussion

The study compared the technology curriculum of the school with that of the university. The data was taken from the school curriculum for the subject technology, i.e. CAPS grades 7–9 and the university curriculum for the technology course, i.e. levels 2–4. The content is taught at university only from level 2, because at level 1, students are taught only the background and development of technology.

In technology education, there are four themes to be covered during the year that are supported by the methodology for technology. These themes encompass a variety of topics that are presented in order to complete the methodological process, which is called the backbone of the technological process. This methodology is called the technological process or design process. As each theme is presented, it is integrated with the relevant technological process thereby providing an output in a form of a prototype. Table 1 shows topics that appear in both curriculums, topics that are only in the school curriculum, topics that are only in the university curriculum and topics that are only covered practically. Technology education as a subject, both at school and university, must integrate the theoretical components with the practical.

Table 1 above shows the topics covered by the university curriculum, as well as the school curriculum. The data in row 1 shows the topics covered in both curriculums. The data shows that approximately 60 per cent of the topics are covered in both curriculums. The data in row 2 illustrates the CB which includes topics in the school curriculum but not in the university curriculum. The data shows that there are a number of topics not presented at university but which students are expected to teach at school level. Row 3 indicates CSs which are topics that are in the university curriculum only but are not clearly shown as being in the school curriculum. These topics do not indicate any relevance to CB or development of CD. Therefore, this means that these topics predominantly reflect CSs rather than CB. The data indicate that, to some extent, the university curriculum is partially relevant but not comprehensive enough in terms of covering all the topics required by the school curriculum. However, the CD of this curriculum, which includes practical components, should be explored.

Table 1: Technology curriculums

Topics in both curriculums	Content breadth (CB)	Content strands (CSs)
STRUCTURE Classification of structures: natural and man-made; Types and definition of structures: shell, frame and solid; Stiffen materials/structure: triangulation, tubing and folding; Materials to ensure stability, strength and rigidity; Define frame structure; Purpose of structural members/components in wood and steel roof trusses (king and queen post, strut, tie, rafter, tie beam); Types of forces (shear, torsion, tension, compression); Types of bridges (beam, suspension bridge, etc.); Structural failure: Forces can be static or dynamic; Load can be even or uneven	**STRUCTURE** Pylons	**STRUCTURE** Processing soil Types of soil; Processing soil to build; Choosing best soil to make mud bricks; Different types of bricks; Different methods of making bricks
PROPERTIES OF MATERIALS Properties of various construction materials: Mass/density; hardness; stiffness; flexibility; corrosion resistance and prevention of corrosion. Adapting material to withstand forces (reinforcing concrete, polywood); Metal section (i-beam, angle iron, T-bar etc); Preventing metals from corrosion assembling	**PROCESSING MATERIALS** Textiles used by fire- fighter/ NSRI or dangerous profession Plastic bags (bio-degradable plastic shopping bags) Packaging of paper and card-board Emergency food	**PROCESSING MATERIALS** Types of food that can be pre-served; Different methods of preserv-ing food

ELECTRICAL SYSTEMS Simple electric circuit (cell, switch, conductor and a bulb or buzzer; Components symbols: Simple circuit components and their accepted symbols using input devices: electrochemical cell, generator, solar panel; output devices: resistor, lamp, heater, buzzer, motor and control device: switch); Advantage and disadvantage of series and parallel circuit; Logic gates (AND AND/OR logic gates); Introduction of Ohm's law; Resistance colour codes; Control switches: push, SPT, SPDT, DPDT; Diodes and LED; Transistors; Sensors: input devices: LDR (light-dependent resistor); thermistor; Touch or moisture detector; Capacitors; Simple electronic circuit: assembling	**ELECTRICAL SYSTEM** Simple circuit components and their accepted symbols using (input devices: generator, solar panel; output devices: heater, buzzer, motor). Making batteries using fruit, vegetable and salt water batteries . NPN Transistor	**ELECTRICAL SYSTEM** Different methods of moulding
MECHANICAL SYSTEMS Levers; Linkages; Cranks; Pulleys; Belt drives; Chain and sprocket systems; Gear and gearing; Spur gears; Other types of gear; Hydraulics; transmitting forces in a hydraulic; Mechanical advantage of a hydraulic system; Controlling hydraulic system; Advised hydraulic systems; Advantage and disadvantage of hydraulics	**MECHANICAL SYSTEMS** The wedge (inclined plane or ramp, door wedge, knife blade etc).	**MECHANICAL SYSTEMS**

Conclusion

The study found that the technology course at university reflects integration between itself and the school curriculum with reference to CB. This paper has investigated the types of content knowledge that the university curriculum emphasises when developing a teacher training programme. It explores, on the one hand, whether the university curriculum emphasises CB (specific subject content knowledge) that is relevant to the level at which students will be teaching, or CSs (any technology subject domain concepts), or whether, on the other hand, it addresses the school's CB (subject content knowledge) that is relevant, and then moves on to the CD of the concepts.

Firstly, the findings of the study indicate that the university technology curriculum includes a number of topics that are required by the school technology curriculum. This means that the university technology curriculum does place emphasis on the school CB (specific content knowledge). However, the data also indicates that there are some topics required by the school CB that the university does not cover. This is in contrast with Brown's approach (2009) arguing subjects at both school and university must complement each other regarding the themes and topics to be covered. Lastly, the data also indicate that there are some CSs covered by the university technology curriculum that cannot be considered to develop CD. As a result, these CS topics are neither associated with any CB nor established in order to cultivate the CD.

In conclusion, the study has found that the university technology curriculum places its emphasis on both CB and CSs. However, some of the CSs that were introduced into the university technology curriculum have no relevance to the CB, nor are designed to develop the CD of CB. Therefore, this means that the CSs of the university technology curriculum have not been designed to focus on the notion of 'fitness-for-purpose' which is market driven. However, it is imperative that students be given an opportunity to explore both CB and CD as well as how other CSs can be used to develop a deeper understanding of CB. Although the findings of this study cannot be generalized, because only one university was observed, the study's results could be used in other similar contexts.

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