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Research Article

Pedagogies of Transferring Multidisciplinary and Integrated Knowledge Through a Curriculum Designed for Preservice Sciences Teacher Education

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Abstract

This study explored teacher educators' conceptions of adequate educators' preparation to teach school curriculum through principle of knowledge integration. Interpretive research paradigm through employing qualitative research approach through multiple case studies of purposively sampled universities was used. Science Teacher Educators in this study were interviewed with a purpose to view their perspectives of what knowledge integration entails and how it informed their curriculum design and development to train and develop 21st century teachers. Lecturers suggested clustering knowledge from different sciences knowledge domains through thematic and modular approaches to integrate related knowledge in teaching science education. This study discovered emergence of shifting from using conventional curriculum programming to make an allowance for knowledge integration which ushers in a curriculum that is aligned to school curriculum, with depth in content knowledge and practical competencies required in inquiry-based nature of science.

Introduction

Both opponents and supporters of the principle of integration in the constructivist curriculum for post-apartheid education in South Africa express their concerns about implementing integration in Sciences education.

Issues raised among others are:

Preparation of teachers: Teachers require a theoretical basis for integration as well as aims and methods for the programme. If skills-based teaching, Freirean priorities and open participation in curriculum development are to be achieved in the classroom, then pre-service teachers need to be trained in accordance with such principles and goals.

Competencies required from teachers to implement integration include the ability:

a) To analyse information from various resources,

b) To formulate learning objectives that enhance integration, and

c) To select learning experiences that enable learners to transfer skills across disciplines and assess them adequately.

Resources to support implementation in classrooms: Currently, integrated studies are introduced at school level as part of constructivist, post-apartheid curriculum development which aims to nurture egalitarian values, diversity, and critical thinking. Implementation requires support within the school, resources, and texts to support curriculum innovations and educational transformation from segregated schools to mixed, competitive and democratically orientated schools. Research conducted by a consortium of researchers from the Centre for Education Policy Development (CEPD), Human Science Research Council (HSRC), Centre for Evaluation and Assessment and South African Institute for Distance Education (SAIDE) proposed guidelines for

development of curricula for teacher education and training. The guiding principle behind the model of curriculum for teacher education and training was 'integration' [1]. Integration in teacher education and training implied: linking theory and practice, which was possible through acquisition of competences: for example, foundational competence (mastery of knowledge in the discipline), practical competence (skills and abilities) and reflexive competence. Harley and Wedekind (2004: 195) argue that 'curriculum will begin to integrate education and training - incorporating a view of learning which rejects rigid division between academic and applied knowledge, theory and practice, and knowledge and skills.

Literature Review

Integration of knowledge, as perceived by certain scholars and researchers [2-5] in the field of education is twofold; referring to approaches to pedagogy, and to subject knowledge structure. According to Golding , there are three domains in epistemic structure: dualism, relativism, and critical pluralism. Dualists regard knowledge as objective, certain and absolute. Scholars of this school of thought view knowledge and the world in terms of facts. Relativists, however, think of knowledge as subjective: including individual beliefs and theories. To a relativist thinker, values and therefore knowledge are contextual and contingent [6]. The critical pluralist contends that knowledge is absolute in nature. Critical pluralists in educational research emphasise critical, reflective and inter-subjective approaches to knowledge structuring. Golding reflects on this trend as a shift from the dual approach to epistemic research, to an inter-disciplinary approach.

The review of literature germane to the topic of integrated learning in the South African curriculum, embraces a wide range of issues or aspects of curriculum research in South Africa:

a) Historical perspectives of curriculum development for teacher qualifications in Higher Education Institutions from 1994 to 2011.

b) The contesting views about the alignment of Teacher Education curriculum with the demands of the school curriculum from the advocacy of curriculum changes in school curriculum called Curriculum 2005 to National Curriculum Statement as well as Curriculum and Assessment Policy Statement.

c) Lastly, the transformation of Higher Education Institutions.

Discussion of these issues provided the background to the argument of the selection and organization of the sciences curriculum for teachers' education and training in higher education institutions that is pursued in this study. Researchers both locally and internationally have highlighted in their findings that the quality of teachers prepared to implement curriculum changes in schools is poor; thus, learner performance is not improving [7-15]. In the same vein, researchers in higher education, specifically regarding teacher education, pointed to the curriculum for teachers 'qualification to be problematic' [16]. The revised policy for teacher education and training has pointed to the issue of disciplinary knowledge and specialized content knowledge and specialized subject pedagogical content knowledge as the main issues of consideration in the Minimum Requirement for Teacher Qualification [17]. Literature [18-21] indicates that both opponents and supporters of the principle of integration in the alternative curriculum for post-apartheid education expressed similar concerns about implementation of the integration of knowledge particularly regarding the following.

Preparation of teachers: Teachers require a theoretical basis for the approach to integration as well as aims and methods of the program. If skills-based teaching and alternative teaching methods and learning styles, and open participation in the curriculum development are to be achieved as pedagogic desiderata, pre-service and in-service education and training are necessary to improve teachers' knowledge and skills.

Competencies required from teachers to implement integration include the ability:

a) to analyse information from various resources,

b) formulate learning objectives that enhances integration and

c) select learning experiences in a manner that learners are able to transfer skills across the disciplines in that field and to assess adequately.

Resources to support implementation in classrooms: Integration studies are introduced as a school-based curriculum development. Implementation requires support within the school, resources, and text to support curriculum innovations. Researchers in educational and curriculum field of study [21-25] advocated a radical shift away from the teaching of subjects in separate 'silos' in the school curriculum. The trend of integrating disciplines into broad field of study emanated from the view held by proponents of the integrated approach to teaching and learning of knowledge [26,27]. This perspective is underpinned by the view of the rapid changes in the modern world which demand scientific innovations and advancement in knowledge based on inquiry and research [28] argues that science education should equip learners with skills such as critical thinking, problem solving, and knowledge construction informed by scientific research. Pioneers of the 21st century constructivist curriculum emphasize that for science learners to cope with the pressures of the rapid changes and pressures of economic competitiveness, science education must focus upon fostering deep content knowledge through active

intellectual engagement and emulation of disciplinary practices [29-31] contends that the 21st century is the age of relevance and accountability; pedagogies and standards of knowledge have to ensure that Sciences learners are exposed to global perspectives through interdisciplinary, intra-disciplinary and multidisciplinary teaching and learning: construction of the Sciences' conceptual realm should be constructed from integrated disciplines in the field of Sciences that pertain to biosphere, hydrosphere and stratosphere which integrates the content knowledge of several disciplines. The assumed challenge for Sciences teacher educators is to engage in educating pre-service teachers through both disciplinary and interdisciplinary expertise. This larger context creates depth in content knowledge across related disciplines that form one discipline. Golding insinuates that interdisciplinary education needs to educate individuals to excel in all respective disciplines that contribute to the formation of a multi-disciplinary field: such a practice ensures that interdisciplinary education goes deep in discipline knowledge acquisition through relevant teaching and learning strategies [32]. so that students can learn to respond to challenges that transcend disciplines within the confluence of multiple disciplines. The added advantage of this confluence of disciplines is development of research trajectories that do not conform to standard disciplinary paths [33].

Theories Influencing the Teaching and Learning of the Sciences Curriculum

The synthesis of literature indicated that the theoretical principles underpinning the conceptual pedagogical knowledge for Life Science teacher education drew upon philosophical beliefs of both positivism and constructivist realists [34-36]. Literature indicates that research into approaches concerning epistemic development is influenced by notions of truthfulness, objectivity, and universality in knowledge [35,36]. The perspective that upholds this belief about the theory of knowledge advocated approaches to pedagogy in the fields of Sciences which promotes self-discovery, experimentation, investigation and other deductive and inductive methods of teaching and learning, such as inquiry-based-learning and problem-based learning [37]. Analysis of these pedagogical approaches is critical in this study for it provide the lens through which data collected by means of interviews from Science teacher educators are analysed. Perspectives on the application of these pedagogical approaches in the preparation of pre-service teachers in the field of Science education were used as a mirror against which the responses of the academics' in the departments and schools of Science Education were analysed and conceptualised in the context of knowledge integration.

Methodology

The empirical study was informed by the principles of an interpretivist research paradigm which takes into consideration that every aspect of a qualitative study matters and must be treated as a potential source of data. A case study was conducted on Sciences teacher educators sampled from South African Higher Education Institutions that had undergone a process of merging: colleges of education, teacher training institutions and traditional universities were amalgamated in various ways. The rationale for selecting two universities as separate case studies in this article from a population of 23 public universities was to target the different attributes and characteristic features of those establishments that still profess to train and develop science pre-service teachers. A purposive sampling strategy was therefore used to select two universities which went through the process of merging in different provinces. From each university, three respondents were approached to participate in the multiple case study. In-depth interviews were conducted as primary data collection method. For purposes of triangulating data obtained from interviews, curriculum documents developed for natural sciences and FET Sciences were solicited for further document analysis and synthesis of data [38,39]. Open coding was followed by identification of themes which were used as tools to address the broader research aim and to answer research questions. According to ' [40] open coding' was considered in this study as an inductive process; whereby the codes are selected according to what the data signify to the researcher. The researcher in this case needed an overview of as much contextual data as possible [41]. Qualitative transcripts or discursive data assisted the researcher to analyse data by breaking it into units which culminated into themes, patterns, trends and relations. The data gathered by means of document analysis were analysed qualitatively following suggestions [42-45]. According to Mouton, the documentary sources are useful to provide evidence of the data already been gathered. Data collected by means of document analysis were analysed by integrating and collating views and trends in the patterns and layouts. Philosophical inclinations and lecturers' beliefs and view of how knowledge is produced and how their trend of thought would influence the envisaged competent science teachers comprised a pivotal process of data processing.

Results and Discussion

Vertical articulation of knowledge: Consideration of cross-disciplinary knowledge integration in curriculum design and development

Data analysis identified patterns and trends of thought which indicated that academics participating in the sample emphasised that themes and topics selected for academic content in sub-disciplines [in the field of Sciences such as, Physical Science, Chemistry, Geography, Animal Kingdom and Plant Kingdom in Sciences] should be vertically articulated.

Respondent X in Case D stated that

As we start with the new curriculum, if it is physical science students, they must take Sciences and geography. For Sciences you

have to take geography and physical science from the first year. We started this year, 2017 to implement this, because we had a problem in conceptualising the curriculum to meet the expectations of the policy MRTEQ and we are continuing to fix it.

Respondent G claims that

a) The strength of integration of disciplines to form a multidisciplinary subject is that you deal with many, different strands, or variety of topics per term or in a semester.

b) Integration of discrete competences within Sciences Curriculum design and development was demonstrated when respondent H stated.

c) A lot of disciplinary approaches is what I prefer. Systematic approach is what I follow e.g. Zoology, Botany, Microbiology are organised in a systematic approach from species upwards to the most complex e. g. Plant kingdom, animal kingdom. It lays a good foundation with the principle of taxonomy but over the years this changed and interdisciplinary and integrated approach was introduced becoming a thematic approach.

The same sentiment was linked to the following statement made by respondent T

My teaching of Sciences could both carry strengths and weaknesses, the fact that it goes from a cellular level to a systems level. Concerning the probing question of why it is important to organize academic disciplinary content in a continuum or spiral form, respondent Y stated that. Because we start in the first year with basics of the scientific method, basic biochemistry, and basic ecology, first these topics are best for them to get prepared for what is coming in the second year in terms of topics like photosynthesis and respiration in plants. It is a strength meaning that the students are better and it lays a very good foundation for the next lecturers to build on the foundation already laid… then they get to see the bigger picture of the curriculum of the Sciences over these 3 or 4 years.

Finding: Emphasis on the clustering of themes highlighted that this pattern of thought considered students' psychological needs as expressed in Bruner's Theory of knowledge processing. The principle of starting with simple or basic concepts and working up to complex conceptual knowledge speaks to the view of Bruner's spiral Model for curriculum design and development [46].

Implication: Consideration of students' psychological and cognitive needs implies that academics' conception of curriculum development is informed by research and theoretical principles on curriculum design and development. This study perceives this trend to be of crucial importance: addressing students' needs, particularly at first-year level: research showed that students dropped out when they failed to cope with content and pedagogical approaches in Higher Educational Institutions (HEI's). Academics advocate that knowledge integration is only possible if students are exposed to distinct or disciplinary knowledge first; before they are engaged in any form of integrated knowledge. Such Science teachers are likely to face challenges in implementing Sciences school curriculum. By contrast, however, proponents of knowledge integration for effective knowledge acquisition claim that learners should be encouraged as early as possible in their schooling to make links between subjects which are, in the view of constructivists and integrationists, artificially separated into stifling and unimaginative silos of specialist learning [11,47,48]. It is possible to make a connection here with the issue around Public Management and Political Sciences. There is a school of thought that opines that the two should not necessarily be separate as is the case currently. This view insinuates that it is possible to link so-called Faculties in various institutions of higher learning: faculties differ from university to university meaning the conception of those 'faculties' depends on the inclinations of those who were responsible for designing them. In some universities the Faculty of Humanities comprises disciplines/departments which in some universities belong to the so-called social sciences. In some universities English is housed at the Faculty of Arts whereas in some the Arts Faculty comprises artistic disciplines only.

Linking Academic Disciplinary Content with the School Sciences Curriculum

Another cluster of responses which was noted during data analysis made several cogent points about designing and developing a curriculum for preparing Sciences teachers academically and professionally.

Congruently both cases agreed regarding the issue stated above. The following responses were cited from the manuscripts

I am thinking now of the educational perspective, especially the people we are now sending students in the education world. We need someone to be an expert in physics and an expert in chemistry and in geography. In order to integrate those so that students or learners in front of them will have the best preparation in order for learners to be empowered to choose subjects well in grade 10. Because that is the biggest purpose of integrating those knowledge areas in order for grade 9 learners to know that at the end of that year, what their interests are and to lay foundations so that if they want to choose physical science, the basics of physics and chemistry are covered.

a) Other responses falling under this category emphasised the importance of integrating theoretical knowledge about Sciences subject-content knowledge and Pedagogy.

b) So, I tried to ensure that I also include what is in the school curriculum so that at least our teachers can cope with what is in the curriculum at the moment

c) Respondents emphasised engaging students in practical work which enables them to link academic knowledge in the discipline with school subject content knowledge. This is what respondent X had to say:

d) The practical aspect of the discipline is in the faculty of Science and I only get to involve them into doing group work to design lesson plans for practical work guided by CAPS document. As such time in this university is the impediment especially in this case of practical work.

Finding: Linking academic content knowledge with Sciences content knowledge could be of benefit to Sciences teacher trainees to acquire in-depth subject content as well as its specialised pedagogical content knowledge.

Implication: This study regards this approach to be of benefit to Sciences teacher trainees in applying theory in their practice of teaching Sciences curriculum. Integration of theory learning and practical learning could equip Sciences teachers with competences that contribute to specialist subject knowledge and specialised pedagogical knowledge which relate to knowledge of the learner, teaching strategies, learning styles and assessment procedures [25].

Pedagogical Approaches to Teaching and Learning in Sciences

Data from documentation for case studies [D], the merged institution, did not indicate the strategies of curriculum delivery. The course guide provided a list of assessment methods which were: group discussion, oral presentation and assignment, examinations, and test. Documentation from case study [D] mentioned, self-discovery, problem solving and group discussion as methods. This category embraces the thematic approach as a means of showing interconnections and interrelatedness in selection and organisation of academic content knowledge for sciences teaching in schools. A thematic approach focuses on the vertical articulation of knowledge from basic, simple conceptual and theoretical knowledge to complex and advanced knowledge.

Institution

Analysis of documents from this institution attested to the views of Dialogical Argumentative Instructional Model participant, J in case studies E that the Sciences lecturers preferred this approach to teaching and learning of Sciences in teacher education and training. The King 5 E's model that was alluded to, pioneered the principles of engage, explore, explain, expand, and ensure. The data indicated that views and perceptions on the adequate and suitable approaches to delivering Sciences differed but somehow implicating the same in practice. The convergence of views was identified on the beliefs held by the academics in the Science Education department who participated in the sample, about experimentation, inquiry-based approaches and problem-based learning, active participation. This trend indicates that lecturers in the sample considered to employ learner-centred or student-centred approaches. In the light of transformation in teacher education these approaches are relevant to develop independent and critical thinkers in the field of Sciences.

Engaging Students in the Sharing of Information: Critical and Hermeneutic Paradigms

This issue implies that students' daily life experiences and examples should form the context and content to be used in developing skills for knowledge production. This notion of knowledge context embraces principles of social learning theory and social interactions as a mode of knowledge generation. Emphasises the importance of such social context for the effective learning of concepts and content and [16] explain that a deductive approach enables students to identify various components of phenomena and their interrelations, using logical reasoning. This argument indicates that students can draw their own conclusions through inquiry learning and experiential learning while they unpack definitions and assumptions presented by theorists in subject content knowledge. Barnett emphasizes that assumptions are generated through argumentation which begins with a theory and leads to new assumptions which are tested via comparison with observations, and finally accepted or rejected. This process implies that Sciences students should be engaged in the argumentations so that they will generate their own assumptions based on theoretical knowledge.

The findings of this investigation pointed to the dominance of, and adherence to, the Tyler Model in the conceptualisation of curriculum design by academics. Adherence to Tyler models manifested in such comments as: "A lot was more predetermined; the time curriculum was designed and developed in a systematic way." According to proponents of the Tyler model [29,18,43] this model advocates a systematic process in curriculum design and development. This model emphasizes, first and foremost, a formulation of aims and objectives. Schubert confirms that advocates of this model view curriculum development as a linear process that begins with clearly articulated objectives which predetermine the outcome of the process of learning and the intended learning performance resulting from learning. Selection of content is determined by stated objectives and aims. According to this model, content is described by Ornstein and [8,37] as a vehicle or means through which objectives are attained. Interaction between teacher and learner is based on systematically organised content which, in this model, is inherent in philosophical foundations representing the purpose and aim of education as well as aspirations of the society; content is significant in the teaching and learning context. Grundy links this model with progressivist theories of learning, for example, behaviourism. Ornstein and Hunkins claim that curriculum should transmit a society's culture: acquisition of content knowledge and

cognitive skills are the output of the learning process. Findings of this research project revealed that principles of outcomes-based education influenced some of the thinking during the process of curriculum decision making. Two theories, in particular, King 5E's and Dialogical Argumentation Instructional Models, were cited by some participants and indicated evidence of an emerging discourse; away from traditional trends that dominated teacher training from 1948-1994, conceptualisation which dictated curriculum design and development previously under white Nationalist government.

Conclusion

This empirical study concludes that there is at least some evidence of emergent, enlightened patterns of thought among a few academics which signals a welcome departure from stifling traditionalist restrictions upon teaching and learning of Sciences in higher education. Instead of transmitting knowledge from textbooks, a few lecturers are designing activities around themes and topics which enforce dialogue, argumentation, engagement, exploration, explanation, and development of new, integrated strategies of teaching. These strategies are recommended by pioneers of Mode 2 knowledge integration [20]. Furthermore, the Dialogical Argumentative Instructional Model and the King 5E approaches as progressive pedagogies of training of Sciences teachers is strongly supported. Such enlightened and flexible pedagogical schemata allow for the acquisition of applied competences as prescribed in the curriculum policy for teacher education and training. In Science Education, such approaches have been tested and found suitable in enabling students to develop conceptual knowledge of sciences across cultural and disciplinary divides. This study argues that integration of knowledge should focus on building knowledge from the point of the real-life experiences of students. This argument is influenced by the Critical paradigm and the theory of curriculum called Praxis which emphasises liberation of the mind through teaching and learning; especially the minds of those oppressed by poverty who are not aware of the rich stock of life-knowledge that they already possess; a resource which provides a ready platform for educational development.

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