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With the title

Educators' perceptions of using knowledge integration for teaching Natural Sciences in the Senior Phase.

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Abstract

The knowledge integration perspective has been used mainly in analysing and describing students' learning of science and other subjects, this principle of knowledge integration determined how subject content knowledge should be taught, no longer in the heterogeneous or multi-disciplinary manner employed from 1994 during the post-apartheid curriculum reformation. Knowledge integration identifies links that allow teachers and learners to apply their knowledge flexible and allowing rich descriptions and comparisons of learners' identification of mechanisms or processes that support learning. The study is important for science teacher educators because it illustrates educators' perceptions on using knowledge integration for teaching Natural Sciences in the Senior Phase. Therefore, this research aimed at exploring how educators perceive knowledge integration in their teaching of senior phase Natural Sciences school curriculum. The qualitative research design in the form of case study was adopted on a purposively sampled two educators who teach natural sciences in grade 9 at two schools. Schools were selected based on their location in socio-economically disadvantaged context and an ex-model C school which is relatively located in an affluent area. One school is categorised as quintile 1 school, which is a disadvantaged school which does not require learners to pay school fees and hence operates through government subsidy. The second school is categorised as a quintile 4 school, which requires learners to pay fees in addition to obtaining minimal government subsidy and hence having a better economical status compared to lower quintile schools. In-depth interviews and documents analyses were used as data collection methods. Data collected were coded and analysed thematically. Findings were generated from the emerging themes. This study unveiled that grade 9 educators teach reduced content

in the grade curriculum through using textbook-based methods because of the alleged overloaded curriculum. If the principle of knowledge integration were to be adopted when teaching natural sciences subdisciplines, educators would be able to make links between knowledge in the subjects that form a multidisciplinary subject. In this case, teaching subjects through themes could assist educators to trim or condense the curriculum that appears to be cumbersome. The second major finding of this study is the fact that educators are unwilling to teach natural sciences as an integrated subject due to their passion of their specialisation which leads to over-teaching aspects of the content which teachers are comfortable with while ignoring those that they are not familiar or competent in. If this situation prevails, learners are unlikely to proceed with the science stream as they get to enrol in grade 10 to 12 subjects. This perpetuates the notion of science subjects being viewed as being difficult leading to low enrolments in the science subjects. The resultant effect of this situation is the snowballing lack of critical skills in science-based degrees and career. This study argues against the intervention of Curriculum Advisors who could spearhead the training and retraining of educators on exploring models of knowledge integration and monitoring the success of adoption of such models or lack of success thereof. Among the findings of the study is the voice of educators regarding lack of resources for teaching natural sciences. If knowledge integration was given a space in the natural sciences curriculum, the challenge of lack of resources would be overcome trough integration of ICT knowledge and skills in the curriculum. The world has shifted into the fourth industrial revolution and therefore the sooner the laboratory skills are sourced digitally if they are not available physically would liberate educators to employ Technological Pedagogical Content Knowledge to better address a challenge of lack of resources. Learners are technologically savvy and therefore it is recommended that educators must rethink their pedagogical

strategies to teach school natural science curriculum through integrating various sub disciplinary knowledge with technological skills. The advent of Covid-19 has made researchers to think of novel ways of teaching and learning and integration of knowledges and repacking content in science disciplines has be at the forefront of the research agenda, globally and locally.

Declaration

I, **Tlholohelo Tsotetsi** declare that the work presented in this dissertation with a title: "Educators' perceptions of using knowledge integration for teaching Natural Sciences in the Senior Phase" is my work and where other sources were used for reference, they were acknowledged according to the Harvard system of referencing.

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Ke a leboha!!

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Acronyms

ANC	African National Congress
CAPS	Curriculum Assessment Policy Statement
CMSA	Curriculum Models for South Africa
DBE	Department of Basic Education
DHET	Department of Higher Education and Training
DoE	Department of Education
FET	Further Education and Training
GET	General Education and Training
MRTEQ	Minimum Requirements for Teacher Education Qualification
MST	Mathematics, Science, and Technology
NECC	National Education Crisis Committee
NEPI	National Education Policy Investigation
NQF	National Qualification Framework
OBE	Outcomes Based Education

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Chapter 1: Overview of the study

1.1. Introduction/background

Knowledge integration was introduced as a guiding principle in the adoption of Outcomes Based Education in South Africa (Pretorius 1998:109). Knowledge integration has since been shown effective for improving many natural language processing tasks such as named entity recognition, sentiment analysis, and question answering (Mikolov, 2013; Devlin, 2018). The knowledge integration perspective has been used mainly in analysing and describing students' learning of science and other subjects, this principle of knowledge integration determined how subject content knowledge should be taught: no longer in the heterogeneous or multi-disciplinary manner employed from1948-1994 but according to an integrated knowledge design (Gravette and Geyser, 2004; Jansen and Christie, 1999).Knowledge integration identifies links that allow teachers and learners to apply their knowledge flexible also allowing rich descriptions and comparisons of learners identification of mechanisms or processes that support learning (Putnam and Borko, 2000). Learners identify weaknesses in their knowledge and add new ideas to their repertoire, linking some and distinguishing between others; they also reconcile ideas that appear contradictory (Linn and Hsi, 2000). Knowledge integration involves applying these knowledge integration processes to ideas such as scientific principles, real-world experiences, and classroom-based experiences to develop robust and usable understandings, an integrated curriculum allows children to pursue learning in a holistic way, without the restrictions often imposed by subject boundaries

(Davis, 2003).

Integrated teaching and learning processes enable children to acquire and use basic skills in all the content areas and to develop positive attitudes for continued successful learning throughout the senior grades (Vaswani, 2017).

The new mode of teaching Natural Sciences as an integrated discipline clashed with traditional methods of textbook learning entrenched at many schools in South Africa. Debates about how to teach Natural Sciences were often sparked by the fact that many teachers did not have sufficient disciplinary content knowledge and pedagogical content knowledge to teach Natural Sciences guided by principles of knowledge integration which demonstrate synergy between the three disciplines that form the school natural sciences curriculum (King and Newman, 2000).

Appleton's (2008: 525) revealed that a significant number of Natural Sciences teachers lack the adequate knowledge and skills to impart knowledge without routine reference to the textbook: they lack required competencies in one or more sub-disciplines that have been amalgamated during the liberation curriculum which turned Natural Sciences into a multi-disciplinary integrated subject. This study examines how educators view the paradigm shift concerning teaching Natural Sciences as an integrated subject (Bantwini, 2011; Bansilal, Brijlall and Mkhwanazi, 2014).

The study is important for science teacher educators because it illustrates educators' perceptions on using knowledge integration for teaching Natural Sciences in the Senior Phase. Because many senior phase teachers are learning science content at the same time as they are learning to teach science, investigating their knowledge of instructional representations necessarily includes investigating their developing subject matter knowledge, as well.

1.2. Main Research Question

What are educators' perceptions of knowledge integration in teaching senior phase Natural Sciences?

1.2.1 The sub-questions are:

- What views of senior phase educators on teaching Natural Sciences as a multidisciplinary subject using knowledge integration as stipulated in the CAPS school curriculum?
- How do these perceptions affect how educators teach Natural Sciences?

1.3. Research Aim

To explore how educators, perceive knowledge integration in their teaching of senior phase Natural Sciences school curriculum.

1.3.1 Research Objectives

- Exploring senior phase educators' views on teaching Natural Science as an integrated subject as stipulated in the CAPS school curriculum
- To identify the extent at which educators' perceptions affect the teaching and learning of Natural Sciences in the school curriculum

1.4. Literature Review

This synthesis of relevant literature provides a conceptual and theoretical framework for the study. It identifies ideas, perceptions, and theories regarding knowledge production for subject content. Davis (2001), Morias and Neves (2006) and Vygotsky (1896-1934) inform the theoretical framework for this study; based upon views and ideas elicited from Vygotsky's foundational theory of social constructivism. The perspective generated from the views and ideas raised by these researchers supports perceptions that knowledge produced in individual disciplines has regulation rules, codes that serve as generative principles, syntax or conceptual meanings as well as pedagogical practices. McNeil (2001) claims that academic curriculum promotes a mixture of subject disciplines, and that each discipline has its unique modes of knowledge production in terms of research methodology.

Research indicates that there is a push for homogeneity as a dominant principle of knowledge production, and knowledge integration as a result (Gravette & Geyser, 2004; Minkler & Wellerstein, 2008). Their argument is based upon such factors as rapid changes in the world, increased demand for multi-skilling and an integrated approach to understand new trends.

Research also suggests that an integrated approach to learning is brain compatible. "The brain learns best in real-life, immersion-style multi-path learning fragmented, piecemeal presenting can forever kill the joy and love of learning" (Cer, 2018). The more connections made by the brain, the greater the opportunity for making high level inferences. Integrating the curriculum is also reflective of developmentally appropriate practice (Liu, 2018). The curriculum is integrated so that children's learning occurs primarily through projects, themes, or topics that reflect children's

interests and suggestions. Projects and themes are valuable instructional tools for accommodating all learners in the classroom (Wu, 2016).

Educational researchers have found that an integrated curriculum can result in greater intellectual curiosity, improved attitude towards schooling, enhanced problem-solving skills, and higher achievement in college (Austin, Hirstein, & Walen, 1997; Kain, 1993). Barab and Landa (1997) indicated that when students focus on problems worth solving, motivation and learning increase. Some schools have used an integrated curriculum as a way to make education relevant and thus a way to keep students interested in school (Kain, 1993)

The principle of integration of knowledge adopted by the National Qualification Framework (NQF) draws upon certain theoretical perspectives such post-modern curriculum programming (DoE, 2008). There are new trends towards broad field curriculum design and development that uphold the view of integration, and interdisciplinary curriculum programming, while others prefer multi-disciplinary programming (Slattery, 2010; Apple, 2004; Gravette and Geyser, 2004; Fullan, 2006).

The new trend towards broad field curriculum design is opposite to discipline- or subject-based curriculum programming. Researchers advocating a subject-based approach support the separation of discipline knowledge into silos: they strive for the so-called ‘academic’ approach to knowledge production by which each individual science subject has a distinct and organising character or essence (Lample and Conneau, 2019). Proponents of subject-based curriculum support the distinctive qualities subjects: they argue that each discipline has its own discrete philosophical and theoretical foundations.

Broad field and integration curriculum programming in their view compromises the value of subject knowledge production. However, according to Gibbons *et al.,* (1994), the shift from disconnected disciplines to one broad field of study, enables learners to transfer knowledge and skills in the process of learning because of the wider scope of exploration without limitations of disciplinary boundaries.

Minkler and Wellerstein, (2008) and Wilmsen, (2008) point out that the shift away from separate disciplines or a taxonomy of disciplines, towards amalgamation of disciplines, requires educators to adopt participatory research approaches for knowledge production. This shift away from dichotomised knowledge to one broad field of study enables students to

(i). transfer knowledge and skills in the process of learning,

(ii) discern patterns in related areas,

(iii) explore a wider field of knowledge without limitations of boundaries, and

(iv) apply knowledge gained in what was a separate area before to what become closely related areas of knowledge (Higgs, 2003).

Pioneers of a multi-disciplinary approach in South Africa describe such clustering of subjects into Learning Areas and the principles of knowledge integration underpinning curriculum model as part of general curriculum reforms suited to transformation of what was, before liberation, a systemically segregated and classified society (British Imperial,1905-1948 and Afrikaner Nationalist 1948-1994) into a new egalitarian and classless democratic society in South Africa (Nkomo,1998 and NQF,1997, DoE, 1997 and Gravette & Geyser, 2004). Jansen and Christie (1998) refer to a multi-disciplinary paradigm in teacher education and training as hybridisation of knowledge; creating a new breed of educators trained under the

auspices of MRTEQ (2011; 2015) who are better able to address the current need for socio-political and economic equality, as stated in the problem statement that prompted this study.

1.5. Theoretical Framework

This study is supported by two theories: Vygotsky's theory of social constructivism and critical pedagogy. Social constructivism indicates that what people learn is largely about participating in various communities. Meaning resides among people and is made sense of from a particular (cultural) perspective. The socio-cultural context is both where learning takes place or where knowledge is constructed as well as being part of what is learned (Cole, 1996). So, what is learned is always social and, therefore, all knowledge carries social and cultural meanings. Even what appears to be solitary learning acquires a social character since people learn as members of social and cultural groups and what they learn is related to social practices that are enacted in communities. Bakhtin argues that language, perhaps the most powerful of cultural tools, is far from a neutral medium since is it is "overpopulated with the intentions of others" (Bakhtin 1981, p. 294). Language, the learning tool extraordinaire, is saturated with social, cultural and historical meanings; therefore, learning mediated by language – as is usually the case for higher order learning – always manifests a social character. Given that the primary tool for learning, language, is imbued with a social and cultural quality, even what appears to be solitary learning has a social character. This theory is used to analyse the findings of this study in identifying the new syntax and semantics used to describe (i) integrated knowledge in Natural Sciences and (ii) how educators perceive of, and demonstrate, the teaching and learning of Natural Sciences as an integrated tri-disciplinary school curriculum. The theory of social construction of learning presents

learning as a social and cultural process that occurs in the context of human relations and activity, not “in the heads” of individual learners. In this “social” formulation of learning, the socio-cultural context is not the location of learning. The socio-cultural context affects *how* people learn, through participation in cultural activities, and *what* is learned as social practices and is itself part of what is learned. Crucially, psychological (learning) processes are not independent of the socio-cultural context; indeed, they are constituted by the context of which they are a part (Cole 1996; Gee, 2008).

A second theory is used in this study as a lens to collect and analyse data is critical pedagogy. Giroux (2010) declares that critical pedagogy is a philosophy of education and social movement that combines education with critical theory. The study is built upon critical pedagogy in teacher education because of the goal of preparing learners to become active citizens able to contribute meaningfully to their communities and country.

Critical pedagogy is presented in literature as teaching philosophy which takes various aspects into consideration: such as how people think, read, write, and speak which goes into deeper meanings, first impressions, official pronouncements, and mere opinions, to understand the deeper concealed meaning, causes, social context, ideology, and personal consequences of any action, event, object, process, organization, experience, text, subject matter, policy, mass media, or discourse (Shor,1980). This study considers how educators view restructuring of knowledge production as adopted in CAPS policy concerning teaching and learning of Natural Sciences in senior phase (grade 8 and 9).

The neglect of knowledge integration in the Senior Phase curriculum deprives teachers of sciences of an opportunity to learn about the inter-relatedness and inter-

connections between the subject content areas in Sciences. Killen (2015:91) points out that “school learners cannot be expected to integrate knowledge within and across the subject boundaries without considerable guidance of the teacher who is competently trained”.

1.6. Research Design and Methodology

1.6.1. Research Design and Research Paradigm

The design of this study is underpinned by the guidelines for an interpretive paradigm. According to Henning (2004) interpretive research solicits participants' subject views and perceptions about their environment. Such a study requires an interpretivist paradigm. An interpretivist paradigm adopts qualitative inquiry methods for collecting data: qualitative strategies for selecting sample data use of qualitative research instruments, data presentation and analysis in keeping with qualitative research strategies.

Schumacher and McMillan (2006) substantiate the view that an interpretivist paradigm in social research concerns what the world means to the person or group of people being studied. The implication of this paradigm in the empirical study is the interaction between the researcher and participants (Natural Science educators) about the social context (Henning, 2004:20).

The rationale in adopting the above paradigm was to probe deeper the teacher educators' perspectives of knowledge integration vis-à-vis compartmentalising knowledge to maintain disciplinary codes and syntaxes used to regulate how knowledge is taught in its "pure form" without hybridising it with other disciplines. This study seeks to view teachers' perceptions on how knowledge integration which is discussed in depth in the literature review which was seen as being inevitable in the process of curriculum design and development for Natural Science teacher education impacts on their teaching of the discipline content knowledge. Case study design is seen as a research method which will seek to probe deeper on the

participants' views on how Natural Sciences are taught at the selected schools in the Western Cape where the study will be conducted.

1.6.2. Qualitative Research Method.

This study used a qualitative approach. Creswell (1998) refers to qualitative research as an inquiry that explores a social or human problem. Qualitative researchers have a belief that there are situations/ circumstances underlying the matter that led to the study therefore they try to understand those problems.

The qualitative research methodology chosen for this study is based on the assertions of Babbie and Mouton (2007) and Cohen et al. (2010) who proposed the use of qualitative inquiry methods for collecting data. The researcher took into account suggestions made by Henning et al. (2004), Kumar (2005) about conducting a qualitative study: appropriate strategies for selecting the sample, proper design and selection of research instruments, and explicit and clear strategies for data presentation and analysis. Interpretive guidelines proposed by researchers into qualitative paradigm enable this researcher to have a clear understanding of what research design for qualitative inquiry entails. The use of in-depth interviews and unstructured observations are recommended as means of collecting qualitative data in interpretive methodology (Babbie, 2002, Henning et al., 2004, Cohen et al., 2016).

1.6.3.1. Research Design for qualitative study.

The idea of collecting data in different schools in the sampling was informed by the views of Henning et al. (2004) on research design for qualitative studies. This study perceives of each Senior Phase learning institution that participated in the study as a distinct entity in terms of its historical background, contextual factors and

geographical location. The particular phase in the process of curriculum review and development at which each school was involved was taken into consideration in defining each case.

Amongst other things the studies in the process of data collection were reflections on experiences in teaching Natural Sciences [before Outcomes-based principles and transformation of schools were affected] and critical analysis of approaches to Natural Sciences curriculum design and development from Curriculum Assessment Policy Statement (CAPS) Rhetorically, Kumar (2005:112) reiterates that a case study method is a useful approach for studying a social phenomenon through analysis of an individual case out of a group of selected cases. The advantage of using a case study method in this research was to provide an opportunity for the researcher to engage more deeply in analysis of data. Through a case study method, a researcher is able to go beyond and understand the social conditions through the actor's perspective. Case study allows researchers to examine closely the data within the specific context. Such data provide opportunities for intensive interrogation of specific details often overlooked by other methods.

Multiple case study design can be adopted with real life events that shows numerous sources of evidence through application. The multiple case study research design was used for collecting data to answer the research questions that this study aimed to answer: (1) In what way do educators integrate knowledge in teaching Natural Sciences in the Senior Phase?

(2) How do their perceptions of knowledge integration affect how they teach Natural Sciences in the senior Phase?

1.6.3.2. Site where research is conducted

Most of the South African schools are arranged in terms of quintiles from one to five as determined by the location of the school and the wealth based on the allocation of resources and the context of the community where schools are based (Blease & Condy, 2014). The quintiles range from quintile one schools (schools with few resources, hence no fee schools, mostly underperforming and mostly township schools), to quintile four to five schools that are regarded as well-resourced and are also well-performing schools.

The researcher will choose two secondary schools, one situated in the northern suburb areas which includes the Kraaifontein townships (quintile 1), and a school situated in the southern suburbs (quintile 4/5). The school situated in the Kraaifontein township (quintile 1) has a capacity of more than one thousand learners and about 30 staff members with one deputy principal. The school situated in the southern suburbs (quintile 4/5) has a capacity of less than seven hundred learners. All the schools start from Grade 8 to Grade 12.

The researcher chose the schools based on their performances in Natural Sciences. The two township school (quintile 1) is characterised by the low socio-economic status (non-fee paying school which are supported by the government) and a school in the southern suburbs (quintile 4/5) is a well resourced based on the socio-economic status of parents affording to send their children to such school because of them having better facilities and yet requiring more money for school fees. Township schools are mostly having a challenge of lack adequately qualified educators especially in the sciences disciplines compounded by high teacher: learners' ratio and schools that are situated in the suburbs have enough money to appoint

adequate teachers that are subject specialists and secondly, such schools have an acceptable teacher: learners ratios per class.

1.6.3.3. Target population.

The population in research includes a total collection of all units of analysis about which the researcher wishes to draw specific conclusions. The sample was derived from the population of Senior Secondary schools that offer Natural Sciences in township or peri-urban schools in the Western Cape province of South Africa. It can be argued that using accessible population in a research study is a form of convenience sampling, sampling that involves selecting “a sample that suits the purposes of the study and that is purposive or convenient” (Gall, Borg, & Gall, 1996:227) for a variety of reasons. For this study, one school was selected because of accessibility and the proximity to the area where the researcher works and the second school was selected based on its attributes that matches the purpose of the study.

1.6.3.4. Sampling strategy.

Purposive sampling strategy was selected as the strategy to assist the researcher to select participants who were teaching natural sciences in grade 9. Participants needed to have met the following criteria: firstly, having an experience of teaching grade 9 natural sciences for at least more than one year and secondly, endowed with adequate content and pedagogical knowledge to teach grade 9 natural sciences curriculum. According to, in a case study research design, individual cases are treated as units (Kumar, 2005). Therefore, each school that participated in the study was categorised and classified according to their current and historical socio-political

background, and hence, the schools in the affluent areas were assumed to possess both material and human resources which are required for adequate teaching and learning context for science education compared to Township schools. One participant was selected from each of the 2 schools. It is believed that each school has its own contextual attributes that may influence how teachers integrate knowledge in their teaching of Natural Sciences (Cohen *et al.,* 2016; Mouton, 2000, and Babbie & Mouton, 2007). The experiences faced by teachers in different socio-economic backgrounds have been assumed to be enabling or disabling the enactment of styles and strategies for unpacking and repacking the prescribed school curriculum to ensure that all content prescribed for grade 9 natural sciences could entice learners to continue to specialise in science disciplines when they get to the Further Education and Training (FET) phase when they complete their grade 9 as this is the last grade of the General Education and Training (GET) phase of schooling.

1.6.4. Data collection Instruments

The data was collected through in-depth interviews of participants (two educators from each sampled school) and document analysis on CAPS document and other documents, like teachers' subject files which were made available on request. It should be noted that with educators' subject files, educators were not forced to share such document. CAPS curriculum document is available online and therefore, it is a resource that can be harvested online if not requested from the department of Basic Education. Mouton, (2013) asserts that the documentary sources are useful to provide evidence of the data already gathered. Data collected through document analysis should be analyzed by integrating and collating views and trends in the patterns and layouts in line with the information collected through other qualitative

means. The structured questions were written down before arranging the interviews. Arrangement was made with participants on when it was convenient for interviews to be conducted. Even though the country was under lockdown due to Covid-19 pandemic, the researcher was able to secure appointments with participants with all safety protocols set by the government to contain the spread of the viral infections were observed. Over a span of a month, all interviews were conducted, however, access to schools and exchange of physical documents between the researcher and participants was avoided to ensure safety of both parties.

1.6.5. Data Handling and Analysis

To analyse means to break down a whole into its components or constituent parts. One comes to understand the integrity of the whole through assembly of the parts, (Schwedt, 2007). The collected data for this study were processed through the process of using open coding once audios were transcribed into transcripts and using the observation checklist prepared. In this study, the questions on the interview schedule were designed to look critically at the current state of knowledge integration and to probe deeper on how educators perceive teaching natural sciences as an integrated discipline (as it consists of more than two sub-disciplines) to answer the research questions of this study. Schools were given fictitious names such as S1 for the first school, and S2 for the second school that participated in this research project. The educators were given pseudonyms like **T1** from school **S1**, **T2** from school **S1**, **T3** from school **S2** and **T4** from school **S2**. A transcript made from the audiotape where from each interview was labelled as T1S1 or T2S1 or T3S2 and T4S2, respectively. The numbered responses were coded as numbered lines (L1, L2, L3, etc.). The quotes on the findings and discussion of findings appears as follows (T1S1L5) where possible. The purpose of this exercise was to assist in tracing any quotation mentioned in the analysis and discussion of the findings from data set.

1.6.7. Trustworthiness

According to Kumar (2005) the trustworthiness of research instruments is measured by the ability of an instrument to measure what it was intended to measure. It is crucial for this study to ensure that both interview questions and curriculum documents solicited for triangulation purposes are (i) tested for trustworthiness in answering the three research questions that this study is set out to address and (ii) that the questions in the research instruments clearly articulate what this study is aiming to achieve.

Trustworthiness is addressed by checking consistency and stability of research instruments to adequately address the research question throughout the study. In this study, instruments are designed in such a way that they address the main research question as well as its sub-questions. Consistency of instruments is of paramount importance when a qualitative study is a methodology selected in a study such as this one.

1.6.8. Ethical considerations

The researcher will make sure that the rights and welfare of the participants in the research are protected. Clearance will be obtained from Cape Peninsula University of Technology Ethics committee and Western Cape Department of Education. Informed consent will also be obtained from the schools, teachers, parents and learners to be observed and the teachers to be interviewed. The confidentiality and anonymity of the research respondents will be respected. Participants will also be made aware that if they do not feel comfortable that they do not have to answer

questions and that they could withdraw from the project at any time. The collected data will be made available to the participants, either by email, printed handout or text message.

Preliminary Chapter Division

Chapter One

This chapter presents a background to the study.

Chapter Two

A detailed synthesis of the relevant literature is presented in this chapter.

Chapter Three

The research design with the theoretical framework and methodology adopted for this study are discussed critically in this chapter.

Chapter Four

This chapter summarises data generated in the process of data analysis. In this chapter data are interpreted within the context of the purpose of the research tools. A synthesis of the findings of the study is presented in the context of the research aims and objectives of the study as well as the two theories: Social Constructivism and Critical pedagogy.

Chapter Five

This chapter summarises findings of the study providing conclusions drawn from discussion of research. Conclusions and recommendations are made in this chapter

as well as suggestions for further research are made, presented as recommendations.

Chapter 2: Literature Review

2.1 Introduction

This chapter presents an in-depth synthesis of current research and literature relevant to the topic in order to define, contextualize and introduce accurately key concepts of this study highlighted in chapter one: ‘knowledge integration’, ‘curriculum development; Natural Sciences and CAPS curriculum. Literature indicates that these concepts are associated with various perspectives in educational research and are defined as operational terms in this study. In chapter one, reference is made to the operational use and meaning of these concepts without detailed elaboration. Synthesis of literature provided this study with both local and international readings of these concepts in educational research. Conceptualization of this study was chiefly informed by the views, recommendations and suggestions provided by those scholars and researchers in educational research who pursue philosophical and theoretical means of knowledge construction for meaningful learning.

This review of literature covers a wide range of issues or aspects of curriculum research in South Africa: (i) historical perspectives of curriculum development in school curriculum in the post-apartheid era (ii) contesting views of alignment between teacher experiences during the period of transformation of school curriculum and the current school curriculum (from the advocacy of curriculum changes in school curriculum called Curriculum 2005 to CAPS) and, lastly (iii) the pedagogical strategies for teaching school curriculum. Discussion of these issues provides the background to the argument for teacher empowerment to teach natural science in the senior phase as an integrated discipline. Researchers both locally and international highlight in their findings that the quality of teachers implementing curriculum changes in schools is poor and that learner performance is not improving.

2.2 Background to curriculum development and implementation based on Integration of Knowledge

Various perspectives of what the concept of ‘integration’ entails in knowledge organization and structuring during the processes of curriculum research, design, development and adaptation. Chapter two highlights that the conceptualisation of ‘integration’ in South Africa has implications for curriculum design and development for basic education as well as preparation of teachers to adequately teach natural sciences curriculum through pre-service and in-service teacher development and preparation to cope with the evolving school curriculum in South African Basic Education.

Literature shows that integration of heterogeneous knowledge into broader fields of study takes different forms and meanings: trans-disciplinary, inter-disciplinary and multi-disciplinary (Booi, 2018). Analysis of information gathered from sources reveals that these approaches to knowledge integration developed emerging trends in conceptualisation of curriculum: a paradigm shift took place from what used to be traditional specialised subject knowledge, to fields of aggregated knowledge in the conceptualisation of the school Natural Sciences curriculum (Schubert, 1986 and Pinar, 2012). Similarly, Fogarty, (1991: 62-65) illustrates knowledge integration in various models to enhance understanding of approaches to integration of knowledge within a single discipline (trans-disciplinary); integration across more than one disciple (inter-disciplinary) and integration of knowledge across disciplines (multi-disciplinary). Synthesis of information identified certain converging ideas which were organised and presented under Sub-headings; models for integrated curriculum design, broad field curricula models, philosophic foundations for curriculum design and curriculum development phases.

Literature provides a broad survey of historical developments in South Africa in the five years before the country's general elections of democratically elected government (National Education Crisis Committee, (NECC), 1990, and Nkomo, 1997). The search for a curriculum model for a democratic society by the various committees of the NECC, which is the National Education Policy Investigation (NEPI 1991), recommended a major shift: away from the so-called conventional curriculum policy of textbook learning and syllabus, and towards new trends of thought in line with international standards (Nkomo, 1997 and NEPI, 1991). The committee's recommendations suggest that an alternative curriculum model for a democratic society should be underpinned by the 'principle of integration'. Implementation of these principles according to the project of (NECC, NEPI, 1992: 40-41) was to be introduced through the following:

Curriculum content was to be organized for four phases in the schooling system (junior, senior primary, junior, and senior secondary). The seven school subjects were to be organised into 'Learning Areas'. Social Sciences integrated knowledge of what were Geographical and Historical knowledge, while Natural Sciences integrated into one learning field what were General Science, Chemistry, Geography, Physics and Biology (Helmore & Briska, 2017).

Researchers in the NEPI project argue that an alternative curriculum model for a democratic and non–discriminatory society in South Africa could adopt any form of integration. The NEPI, 1992: 73) argues that:

> "Integrated studies in Curriculum Models for South Africa (CMSA), proposes the extension of an integrated approach to senior primary and junior secondary phases. Integration can take a number of forms, from a loose inquiry-based approach, which is not separated into disciplines, theme

> teaching across disciplines, a multidisciplinary approach where disciplines maintain their identities".

Supporters of integration in curriculum research in South Africa highlight the significance and the benefit of integration of any form when stating (NEPI, 1992: 73) that:

> Integration overcomes the fragmentation of subject knowledge. It allows emphasis on the transfer of skills across fields of knowledge than focus on content knowledge only. Integration promotes task-oriented and participatory learning and as Maton (2017) suggests that it is the basis for a more open-ended and a flexible curriculum that curriculum designers should begin to operate.

Integrated studies in the curriculum replace what may have been worthwhile and tested approaches to knowledge construction in the 1970's, with integration of knowledge: by which teachers are better prepared in content and assessment methods compared to existing dis-integrated disciplines Chuang, Jackson, & Jiang, 2016). Experts were of the view that participatory and task-oriented learning characterised a flexible curriculum which was not possible in the disintegrated model of the past (Tell, Berggren, Brusoni, & Van de Ven, 2017)

Literature indicates that both opponents and supporters of the principle of integration in the alternative curriculum for post-apartheid education expressed their concerns about *implementing* integration (Jansen & Christie, 1998; Themane, 2016).

Preparation of teachers: The key point is that teachers require a theoretical basis for integration, as well as the objectives and methods of the programme. In order to achieve skills-based teaching and alternative teaching methods and learning styles and participation in the development of curricula, pre-service and in-service

education and training are needed to improve existing knowledge of teachers and skills.

The skills needed for teachers to implement integration include: the ability to analyze information from different resources, to formulate learning objectives that enhance integration, and to select learning experiences that enable learners to transfer skills across disciplines and to evaluate them appropriately.

Resources to support classroom implementation: integration studies are established as school-based curriculum design. Implementation needs support within the school, resources, and texts to support innovations in the learning environment.

2.3. Brief Overview of Trends in curriculum research for Senior Phase (SP) and Further Education and Training Phase (FET) under the democratic educational dispensation South Africa.

Literature shows that the recommendations of those supporting integrated studies received favourable consideration from curriculum designers and developers in the education ministry led by the African National Congress (ANC) (DoE, 1997). The advocacy documents on curriculum changes in South Africa stipulated (DoE, 1997: 1) that:

> "Essentially, the new curriculum will effect a shift from one which has been content–based to one which is based on outcomes. This shift aims at equipping all learners with the knowledge, competencies and orientation needed for success after they leave school and have completed their education and training. The curriculum will begin to *integrate* education and training – incorporating a view of learning which rejects a rigid division between academic and applied knowledge, theory and practice, and knowledge and skills" (Maton & Doran, 2017).

Advocacy documents (DoE, 1998: 4-10) integrated what were known to be subjects in the former content-based curriculum into broad-fields called Learning Areas. Definition of curriculum provided a framework for integration:

> "A curriculum is everything planned by the educator which will help develop the learner. All knowledge is integrated; and teaching and learning are not sharply divided".

According to DoE (1997: 11-12), principle of integration was to underpin the processes of curriculum research, design, development, and adaptation. This implies that the process of knowledge production by researchers should: enforce the notion of integrated knowledge system; shift from compartmentalised knowledge into broad clusters of subjects; integrate knowledge and skills, knowledge across Learning Areas or fields of knowledge and lastly integrate learning and assessment as a trend that is pursued by researchers in knowledge production.

The implementation of the principle of integration in knowledge organisation contained in the curriculum guidelines introduced a cluster of so-called Learning Areas. The definition of this term in DoE, 1997: 14) is:

*"*Learning Area is a group of related knowledge, skills, values and attitudes. In the learning process, the learning area should enable the learner to demonstrate the skills, knowledge, values, and attitudes associated with the specific learning area. Learning Areas provide a context for the learning of transferable competences, skills, attitudes, and knowledge (Mohr & Welker, 2017).

Literature highlighted adjustments and continuities in the curriculum for a democratic society had not introduced a fundamental shift from the philosophical foundations of Outcomes Based Education (OBE); particularly for Senior and FET Phase (DoE, 2000, 2005 and 2011). The clustering of subjects into broader fields of study are still

manifesting in Sciences, Life Sciences and Technology, Economic and Management Sciences. Subjects such as Natural Sciences combined themes from different disciplines to structure knowledge into related and relevant themes such as the “earth and beyond theme” which incorporates knowledge from the following disciplines: Geography, environmental sciences, Life Sciences, and Physical Science.

The Minister in the National Department of Basic Education stated that the on-going changes effected in national school curriculum are not fundamental but that the changes are the streamlining of the curriculum to address concerns at the implementation level (DoE, 2011).

Researchers into curriculum studies (Jansen, 1999, Chisholm, 2000 and Jansen and Christie, 1998) who are aligned with researchers of the NEPI, caution that the issue of an integrated approach in the development and dissemination in any curriculum change should first prepare teachers by equipping them with suitable theoretical and practical knowledge. The implications for curriculum change for teachers were embedded in the policies for teacher training as set out. This meant that teacher education and training (both pre-service and in-service) in DoE (1998: 23-38) should prepare teachers to demonstrate the following qualities:

- Focus on achieving outcomes of education rather than merely conveying information.
- Translate learning programmes into an achievable entity.
- Find ways of providing conditions of success in the classroom – a positive learning environment.
- Be creative and innovative.

Interpreting and designing a learning programme is associated with the ability or competence of a teacher to select and prepare adequate textual and visual resources; select, sequence and pace learning in a manner that is sensitive to the differing needs of the Learning Area and learners (Maton, Hood & Shay, 2016). Learning Area/ subject/discipline and phase specialist role implies a teacher well-grounded in the relevant knowledge, skills, values, principles, methods and procedures in the discipline or subject and Learning Area phase of the study or professional or occupational practice. Foundational competences were linked to the Learning Area/subject/discipline: phase specialisation, interpreter and designer of the programme role imply that competence must be demonstrated within the subject or phase specialist role that defines the purpose of the qualification (Cer,2018). Practical competence is a demonstrated ability, in an authentic context, to consider a range of possibilities for action, make considered decisions about which possibility to follow and to perform the chosen actions (Igwenagu, 2016).

Reflexive competence is demonstrated when learners demonstrate the ability to integrate or connect performance and decision-making with understanding and the ability to adapt to change and unforeseen circumstances and explain the reasons behind these actions.

Arguments manifested in relevant literature indicate that critics of transformation of teacher education blame rigid regulations and measures of the Council of Higher Education (CHE) as the cause of poor-quality teachers. Researchers who share this view, (Morrow, 2007, Jansen and Christie, 1998) condemn sudden changes in teacher education and particularly issues of regulated roles, competences, and exit outcomes, overloaded curricula, and replacement of a sound theoretical framework for the programme with what they regard as an artificial and mechanistic mapping of regulated imperatives onto courses, units and modules.

In choosing the area of education, and in particular, professional qualifications in education as the focus of this review, the HEQC considered the fundamental role that basic education and the national schooling system have in the development of a democratic society. It also considered the responsibility that higher education institutions have in this regard given their role in the training of teachers both in pre-service and in-service situations. The selection of the specific type of qualifications to be accredited considered the size of the enrolments as well as the strategic importance attached to mathematics and science in the broader developmental goals of the country.

2.4 Critical analysis of various concepts of integration in different educational contexts.

2.4.1 Knowledge Integration

Integration of knowledge, as perceived by certain scholars and researchers (Young, 2010; Kutti, 2007, Golding, 2009, Nikitina, 2002 and Repko, 2007) in the field of education is twofold; referring to approaches to pedagogy, and to subject knowledge structure. According to Golding (2009: 18), 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 think of knowledge as subjective: including individual beliefs and theories. To a relativist thinker, values and therefore knowledge are contextual and contingent (Hoadley, 2014). 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 (2009) reflects on this trend as a shift from the dual approach to epistemic research, to an inter-disciplinary approach.

2.4.2 Images of integrating knowledge into curricula.

Literature shows that integration of knowledge into a curriculum manifest some of the following images. The first group of models depicts integration of knowledge within a single discipline. Integration could take any of the following forms: fragmented models, connected models and nested models.

2.4.2.1 Integration within single-discipline models.

Fragmented model: regarding integration of knowledge within the same discipline. This view of knowledge integration advances the uniqueness of knowledge (taking into consideration that the discipline is the same). According to Killen (2015), outcomes-based curricula introduced in South Africa propose integration of learning outcomes within the Learning Area which is called *within Learning Area integration*. Gibson (1994), Kutti (2007) and Repko (2007) argue that this integration involves transferring skills and enhances the effective development of conceptual knowledge in the learning of disciplinary knowledge.

The Connected model: This is another model that advocates integrating knowledge within a single discipline. The key to this model is the deliberate effort to relate ideas within the discipline, rather than assuming the student will automatically understand the connections. Hartzler (2000) posits that this model of knowledge integration relies upon units as organisers for students to notice interconnections of ideas and skills within a discipline.

Drake (1998) purports that ‘integration is inherently interdisciplinary; involving design with horizontal organizations that break down walls of traditional academic disciplines by providing learning experiences that explicitly link content, skills, and/or values of different areas with the same subject area, but more commonly, between two or more of the traditional academic disciplines’. The integrated curriculum provides the context for learning; however, ‘instructional practices must make these connections explicit’ (Hartzler, 2000: 155).

2.4.2.2 Integration within and across traditional subject boundaries.

The immersed model for integrating knowledge filters all content through the lens of interest and expertise. In this model, integration takes place among learners, with little or no outside intervention.

A network model views the curriculum as a prism which creates dimensions and directions of focus. In this model, learners themselves direct the process of integrating knowledge. It is assumed in this model that only learners themselves, being 'knowers' of intricacies and dimensions of the field, can target the necessary resources as they reach out within and across their area of specialisation. The network model is seen to a limited extent in elementary schools, and, in this case, learners become aware of their areas of interest.

The last curriculum image to be introduced in this thesis takes into account the uniqueness of students; based on their environmental differences and their prior knowledge, what they contribute to the acquisition of meaning-making in a class. Knowledge is constructed and based on students sharing autobiographical accounts with others who strive for understanding. This perspective is demonstrated by Schubert (1986) as a social process whereby individuals reach a point of understanding who they are, who the other partakers of knowledge are, and the nature of the environment in which this knowledge is acquired. These pursuers of knowledge share a mutual space with others who are not in immediate proximity.

2.4.2.3 Integration across several disciplines.

Sequenced model:

The sequenced model, adopted from Fogarty (1991: 62), views the curriculum through lenses that are separate and yet connected by a common frame although topics or units are taught separately; they are re-arranged and sequenced to provide frameworks for related concepts.

Shared model:

A shared model, as adopted from Fogarty (1991:62), views the curriculum through binoculars, bringing two distinct disciplines together into one focussed image. By using overlapping concepts as organising elements, shared models involve shared planning or teaching in two disciplines.

Threaded model:

In this model of knowledge integration, the curriculum is viewed through a magnifying glass. 'Big ideas' are enlarged throughout all content with a meta-curricular approach. This model threads thinking skills, social skills, study skills, graphic organisers, technology and multiple intelligences approaches to learning through all disciplines. In this model, various thinking skills and forms of intelligence supersede all subject matter content: so that production is a skill used in Mathematics, for example, forecasting is used in current events; anticipation is employed in writing a novel, and hypotheses are paramount in the science laboratory. Consensus-seeking strategies are used to resolve conflicts in any problem-solving situation.

Using the idea of meta-curriculum, grade level or inter-departmental teams can target a set of thinking skills to be infused into existing content priorities: thinking skills or social skills are threaded into content.

Integrated model:

An integrated model views a curriculum through interdisciplinary topics that are re-arranged around overlapping concepts, emergent patterns and designs. Using a cross-disciplinary approach, this model blends four major disciplines by identifying overlapping skills, concepts and attitudes. Integration is a result of sifting related ideas out of subject matter content. Integration emerges from within various disciplines and teachers make matches among them as commonalities emerge. An interdisciplinary team discovers they can apply the concept of argument.

Webb model:

This model uses fertile themes to integrate subject matter such as inventions. A cross-departmental team chooses a theme which members use as an overlay for different subjects. Inventions signify the study of technology, science, reading, and writing, designing, and building devices and making flow charts in Mathematics and Computer Technology classes. In departmentalised situations, the Webb curricular approach to integration is often achieved using generic, fertile themes such as patterns. A conceptual theme provides rich possibilities for various disciplines. Patterns or conceptual themes provide fertile ground for cross-disciplinary units of study.

Curriculum integration views education as a process for developing abilities required by Science Education in the twenty-first century rather than as discrete, departmentalized subject matter. All of the definitions of integrated curriculum or interdisciplinary curriculum entail the following approaches (Lipson *et al.,* 1993:252):

> "A combination of subjects; an emphasis on projects, sources that go beyond prescribed textbooks; thematic teaching and learning; experiential education, connection between concepts; connected patterns aimed at presenting meaningful knowledge. Integration avoids the fragmented and irrelevant acquisition of isolated facts and therefore encourages transformation of knowledge into personally useful tools for learning new information; developing enrichment or enhancement activities with a cross-curricular focus including suggestions for cross-curricular "contacts" following each objective; developing assessment

activities that are cross-curricular in nature and including sample planning wheels in all curriculum guides".

2.5 Approaches to integration of knowledge.

Proponents of knowledge integration theory advocate a shift: away from disconnected and fragmented subject or disciplinary knowledge, and towards broad fields of knowledge (Slattery, 2010, Apple, 2004; Gravette and Geyser, 2004 and Fullan, 2006). This theoretical trend contests the generation of knowledge independent of its social, historical, economic and political contexts: the sort of abstraction which is still pursued by academics and researchers at some universities. Theorists who propound the broad field pedagogical model argue that world problems and real-life challenges cannot be addressed by disconnected knowledge (Nowotny *et al.,* 2003, Berkes, 2008 and Gibbons *et al.,* 1994; Golding, 2009; Kutti, 2007).

According to Gibbons *et al.,* (1994), the shift from disconnected disciplines to one broad field of study, Natural Sciences, enables students to transfer knowledge and skills in the process of learning because of the wider scope of exploration without limitations of disciplinary boundaries. Pioneers of a multi-disciplinary approach in South Africa describe clustering of subjects into Learning Areas and the principles of knowledge integration underpinning what was known as the Outcomes Based Education (OBE) curriculum model, now adapted to form CAPS, as curriculum reform (or curriculum for 21st century) for a democratic society in South Africa (Nkomo, 1998 and NQF, 1997, Department of Education and Training, 1997, and Gravette and Geyser, 2004).

Golding (2009) claims that individuals adopting inter-disciplinary approaches to knowledge acquisition can present complex challenges to students which emanate from the complexity and rich interconnectedness that comes from working across what were distinct multiple disciplinary ways of knowing. Problems that seemed insurmountable to students when knowledge was dispensed according to the previous norms (of teaching disciplines in separate 'silos') became manageable in

interdisciplinary modes. In as much as this approach is seen to be challenging to teach, it is necessary if policy stipulations are to be put in place. Individuals gain both ontological and epistemological access to critical knowledge from different disciplines without reducing content. The benefit of this approach is its ability to promote linkages of knowledge across disciplines in thematic thinking, teaching and learning.

Finally, according to researchers in curriculum theory, a curriculum could be developed and designed according to specifications of three broad curriculum theories: descriptive, prescriptive, and critical theory (Kelly, 2009, 2011 and Ornstein and Hunkins, 2014). In respect of the perennial curriculum and a curriculum that pursues technical interest, design and development, models are more inclined to specifications of descriptive theory (Pinar, 2014 and Grundy, 1994). Key features in descriptive theory that are aligned with perennial curriculum and a technical interest curriculum are: principles are value-laden; they use models that control, and direct behaviour and users are unable to see beyond the fetters of narrowly positivistic epistemological, axiological, metaphysical and political bias. Last, empirical-analytic methods are critical in curriculum models (Schubert, 2019).

2.6 Theories influencing the teaching and Learning of Natural Sciences curriculum

2.6.1 Behaviourist Theory

For decades, the conceptualisation of Science disciplines has been influenced by behaviourist school of thought. Behaviourist Models influencing ontological and epistemological foundations on how knowledge is acquired and disseminated were influenced by the trial-and-error method which is based on Thorndike theory which describes an organism's attempt to learn/solve a problem by trying alternative possibilities until a correct solution or desirable outcome is achieved. The premise of this theory involves several attempts to deal and solve problems, motivation to achieve goals, random or purposeful exploration which is fuelled by reward when a desired outcome is achieved. In the same vein, Hull's theory involves variables which are stimulus events systematically manipulated by the experimenter. The behaviourist theory of connectionism exposes how the behaviousts' view to learning

is based on experiments such as instrumental conditioning or connectionism that served to differentiating from Pavlov's classical conditioning from more progressive behavioural theorist like Thorndike. In Thorndike's theory, problem solving is seen as associated with connections between the stimulus and the appropriate responses.

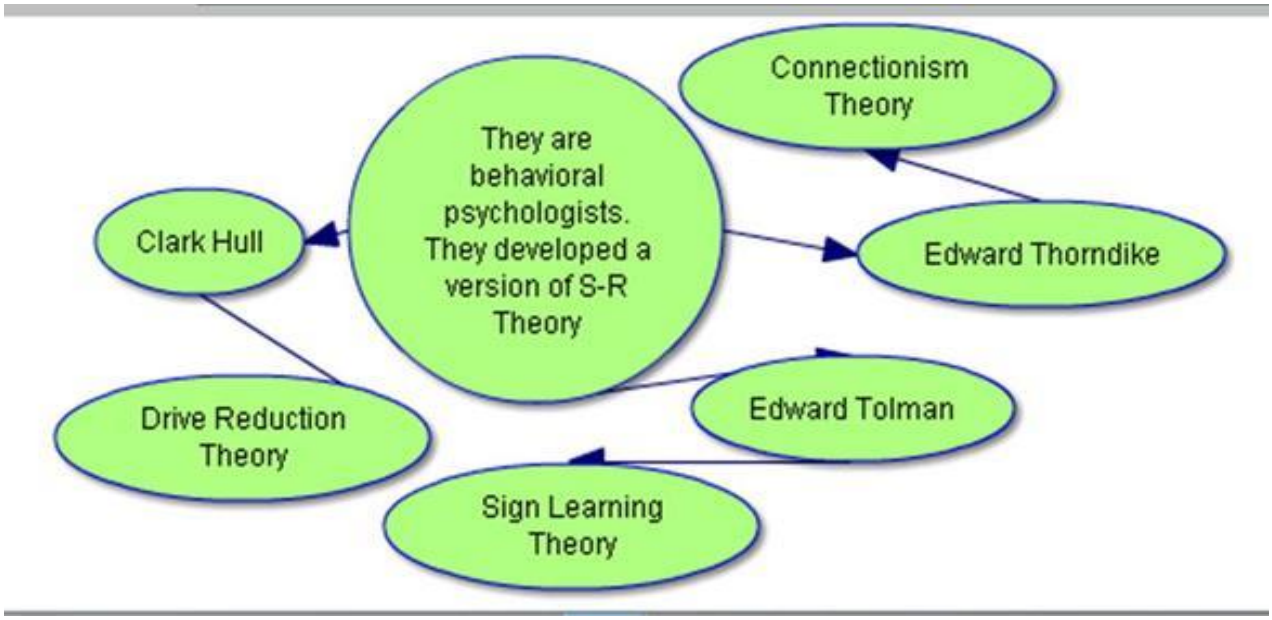

Fig. 1: Illustration how behaviourists have influenced the teaching and learning process of natural sciences disciplines.

The principles underlying Thorndike theory are as follows:

Learning requires both practice and rewards (laws of effect /exercise).

A series of S-R connections can be chained together if they belong to the same action sequence (law of readiness).

Transfer of learning occurs because of previously encountered situations, and

Intelligence is a function of the number of connections learned.

Following the behaviorists' school of thought in the teaching and learning natural sciences curriculum was the emergence of theories that put emphasis on the learners' active involvement in the process of knowledge acquisition. According to Woolfolk, (2001), Ausubel's theory explores how proponents of how the constructivists' view of knowledge acquisition and impartation as exploring how

beings come to know what they learn. This theory, alongside with like-minded theories were viewed in this study as being concerned with how individuals learn large amounts of meaningful material from verbal/textual presentations in a school setting in contrast to theories developed in the context of laboratory experiments. Ausubel's theory asserts that learning is based upon the kinds of superordinate, representational, and combinatorial processes that occur during the reception of information. A primary process in the context of this theory is based on the premise that learning is subsumption in which new material is related to relevant ideas in the existing cognitive structure on a substantive, non-verbatim basis (Woolfolk, 2001). Cognitive structures are therefore viewed as representing the residue of all learning experiences. It is assumed in this context that forgetting occurs because certain details get integrated and lose their individual identity (Hipkiss & Varga,2018). Woolfolk, (1995) therefore argues that Ausubel's theory of learning emphasizes that advance organizers are different from overviews and summaries which simply emphasize key ideas and are presented at the same level of abstraction and generality as the rest of the material. Organizers therefore act as a subsuming bridge between new learning material and existing related ideas.

Further synthesis of literature unraveled the fact the commonalities of Ausubel's with Gestalt theories and those that involve schema (as influenced by Piaget's theory on cognitive development) as a central principle. Literature also unveils similarities with Bruner's "spiral learning" model, although Ausubel emphasizes that subsumption involves reorganization of existing cognitive structures not the development of new structures as constructivist theories suggests (Ausubel, 1968; Woolfolk, 2001).

Ausubel (1968) clearly indicates that his theory applies only to reception (expository) learning in school settings. This theory distinguishes reception learning from rote and discovery learning; the former because it doesn't involve subsumption (i.e., meaningful materials) and the latter because the learner must discover information through actively engaging in the process of problem solving. Many studies have been conducted on the effects of advance organizers in learning (Ausubel, 1968, 1978).

On the other level, Rogers distinguished two types of learning: cognitive (which he view as meaningless) and experiential (assumed as being significant). The former corresponds to academic knowledge such as learning vocabulary or multiplication tables and the latter refers to applied knowledge such as learning about engines to

repair a car. The key to the distinction is that experiential learning addresses the needs and wants of the learner. Rogers lists these qualities of experiential learning: personal involvement, self-initiated, evaluated by learner, and pervasive effects on learner (Woolfolk, 2001).

To Rogers, experiential learning is equivalent to personal change and growth. Rogers feels that all human beings have a natural propensity to learn; the role of the teacher in this case is assumed as that of facilitation during the process of learning. This includes: (1) setting a positive climate for learning, (2) clarifying the purposes of the learner(s), (3) organizing and making available learning resources, (4) balancing intellectual and emotional components of learning, and (5) sharing feelings and thoughts with learners but not being dominating, as is the case with the behaviorists' view to the teaching and learning environment.

According to Rogers, learning is facilitated when: (1) the student participates completely in the learning process and has control over its nature and direction, (2) it is primarily based upon direct confrontation with practical, social, personal or research problems, and (3) self-evaluation is the principal method of assessing progress or success. The importance of learning to learn and an openness to change is viewed by researchers in this philosophical perspective as key attributes that characterize how one comes to know what is to be known. Roger's theory of learning has then evolved as part of the humanistic education movement (Sharma, 2017). Therefore, the implication of Rogers' theory is as follows:

Significant learning takes place when the subject matter is relevant to the personal interests of the student.

Learning which is threatening to the self (e.g., new attitudes or perspectives) are more easily assimilated when external threats are at a minimum.

Learning proceeds faster when the threat to the self is low, and as that,

Self-initiated learning is the most lasting and pervasive.

Sharma, (2017) argues that the integrated approach to teaching of a variety disciplinary science subjects as running under the premise that it embraces our day-

to-day life used as integrated to socio-economical context rather than being presented in fragmented chunks of knowledge; what one needs in his day to day life as knowledge and skill combination are related in one way or the other with some basic facts with principles of sciences. Sharma (*ibid*: 2), posits:

> "One does not need the specialized and deep knowledge as advocated and contained in the specialized branches of science".

The emphasis of the above is based on the premise that, Natural Sciences, stated as general science, can serve the purpose of knowledge links across related disciplines which can serve the purpose of learning well by being science of everyday use and by being essentially elementary and simple in comprehension.

2.6.2 Constructivism

This study is supported by Vygotsky's theory of social constructivism. Social constructivism indicates that what people learn is largely about participating in various communities. Meaning resides among people and is made sense of from a particular (cultural) perspective. The socio-cultural context is both where learning takes place or where knowledge is constructed as well as being part of what is taught (Cole, 1996). So, what is learned is always social and, therefore, all knowledge carries social and cultural meanings. Even what appears to be solitary learning acquires a social character since people learn as members of social and cultural groups and what they learn is related to social practices that are enacted in communities. Bakhtin argues that language, perhaps the most powerful of cultural tools, is far from a neutral medium since is it is "overpopulated with the intentions of others" (Bakhtin 1981, p. 294). Language, the learning tool extraordinaire, is saturated with social, cultural, and historical meanings; therefore, learning mediated by language – as is usually the case for higher order learning – always manifests a social character. Given that the primary tool for learning, language, is imbued with a social and cultural quality, even what appears to be solitary learning has a social character. This theory is used to analyse the findings of this study in identifying the new syntax and semantics used to describe (i) integrated knowledge in Natural Sciences and (ii) how educators perceive of, and demonstrate, the teaching and learning of Natural Sciences as an integrated tri-disciplinary school curriculum. The theory of social construction of learning presents learning as a social and cultural process that occurs in the context of human relations and activity, not "in the heads" of individual learners. In this "social" formulation of learning, the socio-cultural context is not the location of learning. The socio-cultural context affects *how* people learn, through participation in cultural activities, and *what* is learned as social

practices and is itself part of what is learned. Crucially, psychological (learning) processes are not independent of the socio-cultural context; indeed, they are constituted by the context of which they are a part (Cole 1996; Gee, 2008).

In contrast, a social construction of learning emphasizes the profoundly social/cultural character of learning. In this formulation, learning is a process that takes place in participation frameworks and not in the minds of individuals. It is in the context of engagement with participation frameworks that people learn to engage in cultural activities (social practices) that make them into kinds of people (Lave & Wenger 1991). However, people cannot participate or learn to participate in cultural activities or practices on their own. Effective participation in cultural practices requires coordinated activity among members of the cultural community and it is this coordinated activity that is learned. Moreover, coordinated action is *how* learning occurs and *where* it occurs.

The theory of Vygotsky promoted social and cultural contexts of learning which helped children to develop (Allen & Gordon, 2017). He believes that learning takes place through social interactions with adults and peers with the help of psychological tools such as books, diagrams, and electronic devices (Allen & Gordon, 2017). Learners, when they socially interact with one another and work in groups in the classroom, are expected to acquire or produce and apply knowledge and skills in a way that is meaningful to the world or environment that surrounds them. However, Cimer (2011) states that students are experiencing difficulties in so many topics in Natural Sciences such as water transport in plants, respiration, photosynthesis, classification of organisms and many more, and these difficulties negatively affect their motivation and achievement.

2.7. Theoretical Framework

This study is supported by two theories: Vygotsky's theory of social constructivism and critical pedagogy. These two theories are used as a lens in the study to help identify the limits in the study, these theories will also be used to interpret the data and propose the explanations of the underlying causes of the phenomena. The two theories are used to answer the questions in this study.

Social constructivism indicates that what people learn is largely about participating in various communities. Meaning resides among people and is made sense of from a particular (cultural) perspective. The socio-cultural context is both where learning takes place or where knowledge is constructed as well as being part of what is learned (Cole, 1996). So, what is learned is always social and, therefore, all knowledge carries social and cultural meanings. Even what appears to be solitary learning acquires a social character since people learn as members of social and cultural groups and what they learn is related to social practices that are enacted in communities. Bakhtin argues that language, perhaps the most powerful of cultural tools, is far from a neutral medium since is it is "overpopulated with the intentions of others" (Bakhtin 1981, p. 294). Language, the learning tool extraordinaire, is saturated with social, cultural and historical meanings; therefore, learning mediated by language – as is usually the case for higher order learning – always manifests a social character. Given that the primary tool for learning, language, is imbued with a social and cultural quality, even what appears to be solitary learning has a social character. This theory is used to analyse the findings of this study in identifying the new syntax and semantics used to describe (i) integrated knowledge in Natural Sciences and (ii) how educators perceive of, and demonstrate, the teaching and learning of Natural Sciences as an integrated tri-disciplinary school curriculum. The

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biology such as water transport in plants, respiration, photosynthesis, classification of organisms and many more, and these difficulties negatively affect their motivation and achievement.

A second theory is used in this study as a lens to collect and analyse data: critical pedagogy. Giroux (2010) declares that critical pedagogy is a philosophy of education and social movement that combines education with critical theory. The study is built upon critical pedagogy in teacher education because of the goal of preparing learners to become active citizens able to contribute meaningfully to their communities and country.

Critical pedagogy is presented in literature as teaching philosophy which takes various aspects into consideration: such as how people think, read, write, and speak which goes into deeper meanings, first impressions, official pronouncements, and mere opinions, to understand the deeper concealed meaning, causes, social context, ideology, and personal consequences of any action, event, object, process, organization, experience, text, subject matter, policy, mass media, or discourse (Shor,1980). This study considers how educators view restructuring of knowledge production as adopted in CAPS policy concerning teaching and learning of Natural Sciences in senior phase (grade 8 and 9).

Theorist, Max Horkheimer (1937), described a theory as critical because it seeks to liberate human beings from the circumstances that enslave them. The literature highlights language ability as a contributing factor to effective critical thinking skills (Feuerstein, 2007; Nisbett, Peng, Coi & Norenzayan, 2001). Critical thinking skills are regarded as important for problem-solving which strengthens the link between academic language proficiency and critical thinking (Facione, 2009; Halpern, 2007; Haix & Reybold, 2005; Vandermensbrugghe, 2019). Critical theories generally share

a social and cultural analysis with an activist component based largely on the critique of oppressive and dominant economic and political forces. The main focus of this study is to zoom and understand what is happening in the classes of science at different schools in the Senior Phase concerning the use of science concepts how learners learn science in black township schools.

Critical pedagogy is, according to Coffey (2008) an instructional approach, originates from Marxist and Freirean perspective. It is the ability to read texts in an active, reflective manner to better understand power, inequality, and injustice in human relationships. According to Robinson & Robinson (2003), a text is defined as a vehicle through which individuals communicate with one another using the codes and conventions of society. Students can evaluate whose knowledge is being privileged in texts and de-construct the message of those meanings. As readers, learners must also evaluate the social construction of a text and question the factors that may have influenced the author to create the text in a specific manner (Coffey, 2008). Moreover, using critical literacy, teachers should encourage students to look at texts from other perspectives and recreate them from the standpoint of marginalised groups to analyse the power relations and social inequities promoted by the texts. Science education is no different from other fields that require learners to pay attention to text detail. Natural Sciences is the body of knowledge that equips the society with adequate information that is used for the betterment of economic wealth in that society. For the learners to develop the power to be critical when reading a text, they should be able to analyse what each science concept means and be able to develop the necessary understanding of that concept.

2.8 Summary

This chapter presents information elicited through a review of literature for the purpose of identifying theories associated with an empirical study discussed in chapter four. The theories of knowledge and knowledge production were synthesised for the purpose of identifying the perspectives or dimensions that influence beliefs about knowledge organisation and selection of learning experience during curriculum design and development. Underlying principles are as follows:

- The most general ideas of a subject should be presented first and then progressively differentiated in terms of detail and specificity.
- Instructional materials should attempt to integrate new material with previously presented information through comparisons and cross-referencing of new and old ideas.

Chapter 3: Research Design and Methodology

3.1 Introduction

This paper contains discussion of research paradigm and methods that were chosen to carry out the research. The chapter give insight on the procedures used to collect data, the research design, and well as sampling strategies. The research was conducted in two High Schools in the Township school; the results of the research are presented in this chapter under the validation of the research heading.

3.2 Research paradigm, approach, and design

According to Rehman & Alharthi (2016) paradigms serve as the lens or organising principles by which reality is interpreted. This study is supported by an interpretive paradigm. Interpretivism is sometimes referred to as constructivism because it emphasises the ability of the individual to construct meaning (Mack, 2010). Consequently, interpretivists believe that reality is not objectively determined, but is socially constructed (Kelliher, 2005). According to Henning (2004) interpretive research appeal to participants' subjective views and perceptions about their environment. Such a study requires an interpretivist paradigm.

The interpretive paradigm was adopted because it is appropriate for qualitative research design and qualitative methods for data collection and for data analysis. Another important reason for adopting the interpretive paradigm was to explore the educators' perspectives of knowledge integration deeper vis-à-vis compartmentalising knowledge to maintain disciplinary codes and syntaxes used to regulate how knowledge is taught in its "pure form" without hybridising it with other disciplines. This study sought to view teachers' perceptions on how knowledge

integration which is discussed in depth in the literature review which was seen as being inevitable in the process of curriculum design and development for Natural Science teacher education impacts on their teaching of the discipline content knowledge.

Schumacher and McMillan (2006) substantiate the view that an interpretivist paradigm in social research concerns what the world means to the person or group of people being studied. The implication of this paradigm in the empirical study is the interaction between the researcher and participants (Natural Science educators) about the social context (Henning, 2004:20).

An interpretivist paradigm adopts a qualitative approach and strategies for selecting data collection instruments, data presentation and analysis.

Babbie and Mouton (2007) and Babbie (2002) recommend interpretive paradigm for the research that sought to apply, ethnographic studies and multiple studies. As part of an interpretive approach which supports Henning *et al* (2004:20), the researcher had interviews with educators and observed the classrooms and generated information from texts to get more information on the research. Henning et al. (2004) describe interpretive modes of knowledge production as those approaches which are suitable for seeking views, attitudes, experiences and perceptions of participants. In order to understand the phenomenon of Natural Sciences curriculum design and development from the perspective of academics closely involved, the researcher engaged in interpersonal verbal interactions with a sample of academics involved in learner training. As part of an interpretive approach which is in keeping with Henning et al. (2004:20), the researcher interrogated teachers and generated information from texts to extend frames of inquiry into the phenomenon.

3.2.1. Qualitative Research Method.

This study used a qualitative approach. Creswell (1998) refers to qualitative research as an inquiry that explores a social or human problem. Qualitative researchers have a belief that there are situations/ circumstances underlying the matter that led to the study therefore they try to understand those problems.

The qualitative research methodology chosen for this study is based on the assertions of Babbie and Mouton (2007) and Cohen et al. (2010) who proposed the use of qualitative inquiry methods for collecting data. The researcher took into account suggestions made by Henning et al. (2004), Kumar (2005) about conducting a qualitative study: appropriate strategies for selecting the sample, proper design and selection of research instruments, and explicit and clear strategies for data presentation and analysis. Interpretive guidelines proposed by researchers into qualitative paradigm enable this researcher to have a clear understanding of what research design for qualitative inquiry entails. The use of in-depth interviews and unstructured observations are recommended as means of collecting qualitative data in interpretive methodology (Babbie, 2002, Henning et al., 2004, Cohen et al., 2016).

3.2.2. Research Design for qualitative study.

The idea of collecting data in different schools in the sampling was informed by the views of Henning et al. (2004) on research design for qualitative studies. This study perceives of each Senior Phase learning institution that participated in the study as a distinct entity in terms of its historical background, contextual factors and geographical location. The particular phase in the process of curriculum review and

development at which each school was involved was taken into consideration in defining each case.

Amongst other things the studies in the process of data collection were reflections on experiences in teaching Natural Sciences [before Outcomes-based principles and transformation of schools were affected] and critical analysis of approaches to Natural Sciences curriculum design and development from Curriculum Assessment Policy Statement (CAPS) Rhetorically, Kumar (2005:112) reiterates that a case study method is a useful approach for studying a social phenomenon through analysis of an individual case out of a group of selected cases. The advantage of using a case study method in this research was to provide an opportunity for the researcher to engage more deeply in analysis of data. Through a case study design, a researcher is able to go beyond and understand the social conditions through the actor's perspective. Case study allows researchers to examine closely the data within the specific context. Such data provide opportunities for intensive interrogation of specific details often overlooked by other methods.

Multiple case study design can be adopted with real life events that shows numerous sources of evidence through application. The multiple case study research design was used for collecting data to answer the research questions that this study aimed to answer: (1) In what way do educators integrate knowledge in teaching Natural Sciences in the Senior Phase?

(2) How do their perceptions of knowledge integration affect how they teach Natural Sciences in the senior Phase?

3.3. Target population.

Welman et al. (2005) explains, the population encompasses a total collection of all units of analysis about which the researcher wishes to draw specific conclusions. The sample was derived from the population of Senior Secondary schools that offer Natural Sciences in rural schools as per quintiles. It can be argued that using accessible population in a research study is a form of convenience sampling, sampling that involves selecting “a sample that suits the purposes of the study and that is convenient” (Gall, Borg, & Gall, 1996:227) 43 http://etd.uwc.ac.za for a variety of reasons. For this study, one school was selected because of accessibility and the proximity to the area where the researcher works.

3.4. Research Site.

To collect accessible sampling the site was selected in two high schools in the Western Cape, one Kraaifontein Township and the other one from the urban area which is Cape Town in the City Bowl. The two schools were established in the early 70’s,bthe one in the township is located in one of the very impoverished townships, where there is no enough resources at the school, mostly teachers improvise when teaching science to make sure that their learners understand the subject and to also draw interest to the subject. The Township schools was given the codes School 1 (S1) and the participants were given Teacher 1 (T1), and teacher 2 (T2). The school has a high number of learners enrolled, most of the classes are overcrowded with over 40 learners per class. The researcher visited two classes grade 9A and 9C, there were 45 learners in 9A and 51 learners in 9C. The researcher only visited the school twice and conducted the rest of the interviews as well as document analysis telephonically because of COVID-19 protocols.

The second school is situated in the heart of Cape Town, being situated in a very nice area unlike the Township school the school is well equipped with science

resources such as the labs and textbooks, the school was coded School 2 (S2), and the participants were coded Teacher 3 (T3), the school has a low number of learners enrolled for grade 9. In one of the classes visited there were 28 9B's and 30 leaners in 9A. The school was visited twice for interviews and document analysis and rest of the data was collected telephonically because of COVID-19 protocols. The data was collected from the period of March-September.

3.5. Sampling strategy.

The sample for this study was drawn purposively on two Grade 9 Natural Sciences teachers from each of the two schools selected for the study. The teacher from each school teaching Natural Sciences had different qualifications, for example S1 T1 was an African male in his late 50's who held a BA Degree and Post Graduate Certificate in Education (PGCE) and S1 T2 was a male African Teacher in his early 30's who has a Degree in Bachelor of Education. Then in S2 T3 was a Coloured lady in her late 20's who had Education Degree qualification and lastly S2 T4 was an old White male in his 40's who holds a Bachelor of Science Degree (BSc) and Higher Diploma in Education (HDE).

Table below, provides the number of teachers that took part in each school. These teachers were selected because they have been teaching the subject more than 3 years in a Senior Phase in the GET phase. The assumption was that they have a sound knowledge about knowledge integration, this assumption was made after a researcher had an interviews with the participants based on their experiences about knowledge integration that's where the researcher was able to identify participants with sound knowledge about knowledge integration. The aim of using the four teachers in the GET Phase school was to find out how they perceive knowledge

integration in Natural Sciences. The number of learners in each class depended on the class of the chosen school.

Table 1: Sample for the study.

Participants	**Number of schools**		**Technique**	**criteria**
	School 1	School 2		
Classes taught.	2 Grade 9 classes	2 Grade 9 classes	Purposive sampling	2 random schools were selected
Teachers	2 teachers	2 teachers.	Purposive sampling	2 random schools were selected

Determining the proper sampling method is often a difficult task for those employing social scientific research methods. According to Lindgren (1993), competing theories of proper sampling render what constitutes a good sample unclear. Sometimes the guiding advice to sampling selection methods is indirect or abstract to how properly an appropriate sample can be constructed and what the sample can claim to reflect (Lindgren, 1993; Rao, 2000). The type of sampling used in this study was chosen to be purposive sampling. Purposive sampling allows the researcher to choose the respondents that will suit the nature of the study. Richards and Morse (2007) indicate that purposive sampling occurs when the researcher selects a sample because of its characteristics. For this study the samples were logistically in proximity of the researcher. According to Patton (1990), the logic and power of purposeful sampling lies in selecting information-rich cases for the study. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the study.

3.6. Data collection plan.

The study took the route of in-depth interviews of teachers teaching a lesson of Natural Sciences in the Senior Phase. Interviews were collected phonetically via WhatsApp call, each interview took more than 1 hour 30 minutes, because the researcher had to repeat questions making sure that the participant could hear audibly and provide response to a question asked. The researcher used the structured questions because she had specific answers that she was looking for and to cut the airtime costs.

Table 2: Research questions and methods of acquiring data to provide answers to the two questions

Research questions	**Method**	**Instrument**	**respondents**	**analysis**
What views of senior phase educators on teaching Natural Sciences as a multidisciplinary subject using knowledge integration as stipulated in the CAPS school curriculum?	Direct document analysis and taking notes.	Document analysis	Teachers from all two schools	Coding manually.
How do these perceptions	Interviews	Interview	One teacher from	Coding

affect how educators teach Natural Sciences?	(structured interviews)	schedule	each of the sample school (4 teachers)	manually

The study consisted of the following two steps. In the first instance the selected Grade 9 Natural Sciences teachers from each of the three schools were interviewed by the researcher. At each school the teacher's response to the interview questions was recorded and the documents were also analysed using schedule for data analysis. Each teacher was interviewed based on their views on knowledge integration in Natural Sciences. The second step of the study involved interviews with the teachers of each school. Table 2 above presents a summary of the data collection plan used in this study.

3.6.2. Research instruments

The research instruments were used to collect data as informed by the research collection plan. The approach used in this study was qualitative method. Data from document analysis schedule and an interview schedule were used. All interviewees were asked the same questions in the same order. These questions were meant to further investigate what was observed in The CAPS document so as to triangulate the data with the statistical analysis.

3.7. Trustworthiness

3.7.1 Reliability

Means finding the similar results that were found by the previous researcher on the same topic using the same method (Lewis & 49 http://etd.uwc.ac.za Ritchie, 2003). The researcher made teachers aware of the rationale of the study so that they conduct their lessons freely. After the study the researcher showed teachers the transcribed data so that they may check if the researcher information gathered is correct. The above-mentioned approach ensured that any researcher that may come along to do the study again, the similar results be obtained.

3.7.2 Validity

Validity of the data shows how well one's research is looking at the design and the methods of the research. For the interviews, the interview questions focused and were aligned with the research question of the study It generally means that the study's findings truly represent the phenomenon claimed in the study. Document analysis in this study were done through thoroughly looking at the CAPS document of the sessions. The interviews were audiotaped to ensure that all the information given in the study was true. After all of that the data was analysed and it provided the necessary triangulation for the study. The triangulation ensures the credibility and the validity of the data obtained for the study. Methodological triangulation is when one approach is followed by another, to increase confidence in the interpretation (Smith, 2009).

3.8. Ethical consideration

According to Kumar (2005) and McMillan and Schumacher (2006), participants in the study should not by any means be forced to give out information nor be forced to participate on the study. The researcher obtained a clearance form from CPUT and Western Cape Department of Education which ensured the protection of the rights of the participants. The informed consent was also obtained from the school, teachers, parents and learners to be observed and the teachers to be interviewed. The researcher also considered the participants anonymity. The researcher also made aware the respondents that if they do not feel comfortable that they do not have to answer the questions and that they could stop participating anytime if they want to. The collected data was made available to the participants via emails and hand out copies. The researcher shared the data obtained by means of interviews with the participants ensuring that their rights were respected and taken into consideration. The data collection by means of calls was recorded and stored for future purpose it was also shared with the participants. For protection of the participants rights the data was encrypted and the supervisor was able to access it through the researcher.

3.9. Summary.

This chapter outlined the methodology used to collect the data to answer the research questions. The research design of the study was made known. The sampling technique was clarified and justified. It also provided an explanation of the rigor in terms of validity and reliability. In the following chapter the findings of the collected data are presented in the form of tables and graphs.

Chapter 4. Data Presentation, Analysis and Discussion

4.1. Introduction

In the previous chapter the methodology employed to collect the data were presented. This chapter presents the findings of the data collected and presents the data to address the following main research question and sub-questions:

- To establish in what way teachers, integrate knowledge in teaching Natural Science in the Senior Phase
- To identify how their perceptions of knowledge integration affect how they teach Natural Sciences in the Senior Phase

Data presented in the form of themes, trends and patterns were interpreted within the frameworks of the study: research questions, objectives and aims. The theoretical framework obtained during the literature review was used to confirm or reject assumptions of the study.

Data collected through the interviews were treated and using the qualitative thematic approach. The researcher transcribed all recordings from interviews and open coding was used to identify themes that will shed light on the topic researched reflecting the views of participants on the use of the principle of knowledge integration to teach the CAPS Natural Sciences in the school curriculum.

4. 2 Data interpretation and discussions of findings from in-depth interviews and CAPS curriculum document analysis

4.2.1. Research question 1: How do senior phase Natural Sciences educators perceive of the principle of knowledge integration in the teaching of Natural Sciences curriculum?

This section presents data based on the themes emerging from both interviews and document analysis. Themes, findings, and implications of the findings are outlined below.

Theme 1: educators explained that knowledge integration is difficult and is time consuming:

S1explained that '' *sometimes it becomes difficult and frustrating to make science clearer and more understandable to learners''.* Educators perceived difficult nature of science is rooted from the fact that the language of science was uncommon in everyday life and the other subjects' learners learn at school, the content of science is too broad as compared to other subject learnt at the school. Students spent a lot of time to cover science content in preparation towards examinations, and science questions were loaded compared to other subjects. It was a general feeling among the teachers that notwithstanding how much teachers put in teaching science; students still feel they will need extra contact hours outside the regular instructional hours to make it in science.

T2 S2 said: "*I at times had to meet my students after school to teach them whenever they asked for*" and S3T1added that "*I meet my students every Saturday for science lessons*". S3 T2 However did not agree that she must give her students extra hours after the school hours even if they call for. She said: '*'It is true that*

students always call for extra classes for teaching science and you know this attitude is not good for a teacher maximizing time and doing his or her best… I usually don't meet my students for extra classes but assign students with study mates as they learn better from their own friends.

most teachers perceive knowledge integration as difficult not only to them but also to learners, this One teacher said, *''knowledge integration is however difficult because learners may use knowledge they have of the previous subject incorrectly, for example in Natural science, Life Sciences content they are taught about the cell as a basic unit of life again in the same sub discipline in a Physical sciences context they are taught that a cell is an electrical power supply it converts stored chemical into electrical potential energy''*

"*With this concept of integration of knowledge as combining and passing knowledge adequately from different areas to form one key concept. It is difficult to integrate different disciplines because most teachers are not qualified for all the four disciplines, one is either qualified for physical sciences but expected to teach Life Sciences, Geography and Chemistry.*

Findings:

Each discipline should be handled differently through team-teaching. A contrast was identified in other responses which indicated that four components, Geography, Physics, Chemistry and Life Sciences are to be treated as sub-disciplines taught separately as choice subjects on their own with different teachers. 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 the exit of senior phase level,

research shows that many students do not consider taking science in FET when they fail to cope with content and pedagogical approaches in Senior Phase.

Implications:

If teachers are not trained to understand how they could incorporate models of knowledge integration, they would find it difficult with coping with the evolving pedagogical knowledge to teach natural sciences as themes that cut across various disciplines in it. The notion of teachers who doggedly use outdated modes of teaching and learning would hamper their development as professionals. Artificial boundaries created by educators when teaching natural sciences hamper their abilities to learn to make connections in various subject content knowledge and results in a situation of using outdated methods and teaching strategies that would deprive them of opportunities to upgrade and tap on the 21st century skills of teaching sciences. Regular in-service training sessions on knowledge integration could be explored by the Curriculum Advisors to assist teachers to impart knowledge using methods that are relevant to enhance the eradication of critical skills shortages in the society. As they explore the new methods of artistically weaving knowledge across disciplines, they get empowered to empower their learners resulting in the increased interest in students into choosing science related subjects in the FET phase which would increase chances of them choosing sciences related careers.

Theme 2: Educators explained that with this concept of integration of knowledge as combining and passing knowledge adequately, science teaching and learning resources were much needed

The CAPS document which is the main science curriculum material for teaching Integrated Science was quite loaded and there was too much to teach at a particular time especially because most schools do not start exactly with the pacesetter which assumes that students learn on their first day of school which is impossible because most schools start after 3-4 weeks teaching because of admin work they have to do Some of the topics should have been left in the General Education and Training Phase (GET).Teachers felt that CAPS document had lot of expectations and good policies however the application was misunderstood, Policy makers do not understand the situations teachers find themselves in, such as limited teaching resources, overcrowded classrooms and limited time.T2S2 said:

''I *remember when I taught about atoms some of my students said that what they were learning currently at the Senior Phase were almost the same as what they learnt in GET …you see I myself appreciate this and think some of the topics should be pushed to the next grade or be left out if there were dealt with in the previous grade to minimise the content burden on students and teachers.*

Natural Science is informed by knowledge areas that deal with life and living, matter and materials, energy and change, and earth and beyond. These topics stem from various disciplines such as Biology, Chemistry, Physics, and Earth and Space sciences (DBE, 2011). Ecology, geology, and meteorology are three of the nine branches that makes up Natural sciences subject and the teachers were of the firm view that these branches should not have been integrated with the Natural Sciences. This in one way could have helped reduce the load as teachers hardly teach these

aspects such as interactions of organisms with the environment around them, history of the earth and it's life especially as recorded in rocks and atmosphere and it's phenomena, including both weather and climate. T1S3 for instance said: "teachers hardly take students to the field to experience the practical nature of Natural Sciences due to time constraints."

The science materials and equipment were said to be unavailable and where they were available, they were insufficient for effective and efficient science teaching and learning. Most practical lessons in S3 on the classrooms were demonstration based as it was obvious the school did not have enough equipment for students interact within groups or individually

Findings:

Interviews conducted in various schools most educators perceive knowledge integration as difficult and time consuming. Teachers also complain that the content for knowledge integration was loaded and teaching everything for final examination was a difficult task to do, to such an extent that teachers only taught learners the examination-based information and not all content that is meant to be covered as stipulated in the CAPS programme. The utterance of T2S1 explained that the grade 9 learners are usually exam driven. They learn with the aim of obtaining good grades in science so that it is easier for them to qualify for choosing the science stream in the Further Education and Training (FET) Phase, but not to acquire adequate knowledge necessary for them to succeed when they do science disciplines in the exit exams of schooling. "*The students only preferred me teaching those topics which will likely ask questions on in the final exams"*. Teachers generally agreed that in such situations they only had to teach what is based on the examinations and hence stifling opportunities to build on the knowledge that is required for success in

the FET phase. However, CAPS curriculum aims posits that all the topics are important for their personal lives and the communities they live in. Teachers further uttered that good basic knowledge in science will help learners to learn and perform better in Integrated Science and other science related disciplines at the FET and University level.

Implications:

The above findings show that the credibility of grade 9 curriculum is questionable. If educators were to be trained to teach natural sciences curriculum through Fogarty's models of knowledge integration, they would possibly be able to cover a wide range of topic through thematic approach to teaching. If certain sub-disciplines of natural science are ignored, the calibre of learners who come from such knowledge-deprived teaching and learning situations would be found wanting. The purpose of assessing knowledge acquired is wanting as learners are deprived of adequate knowledge that they can build upon as stated in Ausubel's model of teaching and learning and knowledge structuring and sequencing. If the constructivist theory as a pillar of the existing school curriculum were to be used, learners would benefit immensely as they would be actively involved in the process of learning. Science disciplines are learnt better when learners engage in inquiry-based learning and therefore, if the status quo remains, the problem of lack of learners who could chose to do Mathematics, Science and Technology (MST) careers is perpetuated.

Document analysis

Theme 3: Organization of content.

Even though most teachers are not well trained for knowledge integration in schools, the curriculum document layout shows that schools offers both disciplinary content

knowledge and subject content knowledge therefore educators should adapt and successfully integrate knowledge.

Table 3: shows how content is organized in CAPS document in four subject disciplines.

Term 1	**Term 2**	**Term 3**	**Term 4**
Life sciences	Chemistry	**Physical sciences**	Geography

In the first term the Life Sciences content includes: cell structure, systems in the human body, human reproduction, circulatory and respiratory system and digestive systems, ecology. Then in term 2 Under Physical Sciences the focus is on chemical reactions, compounds, acid and bases and pH value. Then term 3 physical sciences deal with Forces, electric cells as energy systems. Then lastly term four Geography focuses on the earth as a system, birth, life, and death of stars. There are four disciples in the CAPS document but only one teacher taught these knowledge areas of science discipline, conjointly at the same time.

The organization of themes in the CAPS curriculum is in line with Forgarty' models of knowledge integration. Hartzler (2000) posits that this model of knowledge integration relies upon units as organisers for students to notice interconnections of ideas and skills within a discipline. In support of this, Drake (1998) argues that 'integration is inherently interdisciplinary; involving design with horizontal organizations that break down walls of traditional academic disciplines by providing learning experiences that explicitly link content, skills, and/or values of different areas with the same subject area, but more commonly, between two or more of the

traditional academic disciplines. Therefore, for natural sciences to be taught as an integrated curriculum it needs to context context for learning; with pedagogical strategies that make these connections of these different disciplines explicit (Hartzler, 2000: 155).

Findings: One of the challenges teachers face in teaching integrated science disciplines, is the loaded nature of the content of the subject. Teachers must teach so much within the limited time frame. Could Natural science educators begin to look at the content of school science studied at each level of school education? This is because there are suggestions that the Natural Sciences aspects of knowledge integration in the science curriculum should be separated and treated as a subject on its own. However, this approach perpetuates the notion of creating artificial boundaries between themes that constitute topics that are taught in natural sciences and defeat the aim of teaching natural sciences as an integrated discipline.

Results from the study have also shown that science teaching materials and equipment were not available in schools and where they are, they were inadequate. The availability of science materials such as textbooks and laboratories has been one of the issues confronting school science (Anderman,2012).

The textbook driven approach used by participants is a demonstration of educators' inadequate content knowledge and skills that are necessary to teach natural sciences as an integrated discipline.

Though findings of the study uncovered that the enabling circumstances are quenched by lack of resources for learners' engagement, science teachers resort to the use of demonstration method as a means of making the best out of the insufficient science teaching and learning equipment they have (Dass & Yager,

2009) but that still denies most students' hands-on experience in the subject (Pryor & Ampiah, 2003)

Therefore, the nature of natural sciences discipline requires educators to be aware of the context where learning should occur so that adjustments could be made to teach natural sciences adequately. As schools were without proper resources, educators are forced to resort to methods that are influenced by behaviourism which influence teacher-centred approaches to teaching and learning as illustrated in Figure 1. Such methods defeat the ends of meaningful learning as they encourage memorisation of facts devoid of knowledge acquisition.

4.2.2. Research question 2: How do these perceptions affect how educators teach Natural Sciences along the principle of integrated knowledge in different sub-disciplines of Natural Sciences?

Theme 4: Student's attitude towards learning science.

Teachers acknowledged that teaching Natural Sciences at a Senior Phase was a challenge as some students had an attitude towards the subject. It was common that one of the student's attitudes towards learning Natural sciences was that they perceived integrated knowledge in science as difficult compared to the other subjects they study in the senior phase level. T1 Another attitude of students which the teachers identified as quite disturbing and not good for science education was students' preference for teachers to teach those topics that are likely to come in the final examination.

During the interviews one of the teachers' revealed learners do not show interest in the subject, to such an extent that many kids do not bring textbooks and writing books to class. At some point those learners who did not have textbooks were not

allowed to share with those who had textbooks because they had to adhere to COVID-19 health protocols, so they end up talking to each other not with the subject related matters. In this case the researcher thought it would be better if the teacher used cooperative method, ensuring that all learners are interested in the subject, because when learners become interested in learning about science early, they will enjoy the subject and choose science in the FET phase, it will also improve their attitude toward the subject. The teacher further argued that if learners do well in all science subjects that would be successful knowledge integration. The researcher looked at the learner's assessments; according to their low performance it was evident that learners lacked interest towards the subject.

Findings:

Results demonstration of learners' lack of interest in the subject at the other schools shows that teachers teaching science are unhappy and lack sufficient knowledge to make the lesson interesting and stimulating interest of learners results in lack of adequate transmission of content knowledge of natural sciences discipline. This could imply that knowledge integration is not as easy therefore for teachers to be able to successfully implement integration they themselves need to be equipped, have resources that will allow the integration of knowledge and they need to be trained as well. If learners were involved in the learning process, educators would in turn benefit from the experience. Learners are social beings, and their prior knowledge and experience could enrich the teaching and learning process, and this could result to positive benefits for future learners especially if social context could be integrated in the classroom for the better understanding of the discipline knowledge. This argument holds because learners influence the learning process (The Association for Science Education, 2006).

Implications:

Lack of resources and proper training for teachers who teach the subject may lead to failure for teachers to successfully teach Natural sciences as an integrated subject. Teachers need to be equipped from universities to be able to teach the subject, so that they have sufficient knowledge in that way it will also help learners to become interested in the subject. The Universities must revisit their curriculum documents so that they produce teachers who are familiar with knowledge intergration.

4.3. Discussion of findings

This study argues that integration of knowledge should focus on, building knowledge from the point of the real-life experiences of students this is influenced by one of the CAPS curriculum document's aims: "This curriculum aims to ensure that children acquire and apply knowledge and skills in ways that are meaningful to their own lives. In this regard, the curriculum promotes knowledge in local contexts, while being sensitive to global imperatives" (DBE, 2011). Even though the curriculum has good policies, but the implementation is somehow poor in a way that most teachers teaching Natural Sciences are not experienced in the four disciplines which then leads them to teaching without engaging learners, in this this case teaching and learning is more centred around the teacher, which then makes a lesson to be less interactive as, when learners are excluded from the lesson they tend to lose interest. The exclusion of the learners from a lesson it's not something a teacher plans but it happens as teachers also are not experienced or have knowledge in some disciplines within the subject which then makes them rely on the textbook or reading from the textbook and unable to explain some questions asked by the learners. According to the theory used in the study which is the behaviorists' school of thought in the teaching and learning Natural Sciences curriculum was the emergence of

theories that put emphasis on the learners' active involvement in the process of knowledge acquisition. According to Woolfolk, (1995), Ausubel's theory explores how proponents of how the constructivists' view of knowledge acquisition and impartation as exploring how beings come to know what they learn.

Lack of laboratories and teaching resources has resulted to Some teachers suggesting that the subject should be separated and be taught by separate teachers however this does not encourage knowledge integration, rather the curriculum should take a burden into account to train teachers in the University level and equip them to be able to teach all the four disciplines successfully. Golding (2009) claims that individuals adopting inter-disciplinary approaches to knowledge acquisition can present complex challenges to students which emanate from the complexity and rich interconnectedness that comes from working across what were distinct multiple disciplinary ways of knowing. Problems that seemed insurmountable to students when knowledge was dispensed according to the previous norms (of teaching disciplines in separate 'silos') became manageable in interdisciplinary modes. In as much as this approach is seen to be challenging to teach, it is necessary if policy stipulations are to be put in place. Individuals gain both ontological and epistemological access to critical knowledge from different disciplines without reducing content. The benefit of this approach is its ability to promote linkages of knowledge across disciplines in thematic thinking, teaching and learn. when teachers are well equipped their role changes in class from being the centre of the lesson, this will help them not to use behaviourism which encourages learners to memorise the work without understanding therefore learners will be more involved. According to researchers in curriculum theory, a curriculum could be developed and designed according to specifications of three broad curriculum theories: descriptive, prescriptive, and critical theory (Kelly, 2009, 2011 and Ornstein and Hunkins, 2014).

In respect of the perennial curriculum and a curriculum that pursues technical interest, design and development, models are more inclined to specifications of descriptive theory (Pinar, 2014 and Grundy, 1994). Ausubel's theory asserts that learning is based upon the kinds of superordinate, representational, and combinatorial processes that occur during the reception of information. A primary process in the context of this theory is based on the premise that learning is subsumption in which new material is related to relevant ideas in the existing cognitive structure on a substantive, non-verbatim basis (Woolfolk, 1995).

4.4. Summary

There are number of challenges facing teachers teaching Integrated Science at the Senior Phase. The challenges are associated with the science materials and equipment, inadequate content knowledge of natural sciences required to prepare learners for continuing with sciences in the FET Phase of schooling with the resultant lack learners' interest in the science subject disciplines and learners' negative attitude towards science. The specifics of these challenges include loaded content of science curriculum, inadequate science teaching materials and equipment, lack of science laboratories. Learners generally have a perception of a difficult nature of sciences. Grade 9 learners' interest in knowing and learning examination-oriented topics only, and students' lack of preparedness towards science lessons is seen in this study as a cause for concern. These challenges in one way or the other, affect the selection of appropriate teaching methods, students' performance in school science, the interest of learners in school science, and lack of learners' participation in science lessons. In the wake of these challenges and their effects on Basic School Science, such challenges are perceived in this study as contributing to the success or lack thereof, of science education in general.

4.5. Limitations of the study

The research was conducted in two high schools. It is difficult therefore to put all the schools under one umbrella of negative assumption and conclude the outcomes across the Western Cape. The sample was very small as the researcher only interviewed four teachers in the schools, so the small amount of the teachers interviewed do not entirely represent the wider population of the province. The researcher's permission to start conducting the practical was accepted late which resulted her having to conduct research within short space of time. Also, the researcher had to also change the school because of unforeseen circumstances. The research was conducted twice a week which made it difficult to compare similar topics taught as outlined in the work schedule. The interviewers kept on rescheduling the interviews because one on one session was a bit difficult to do because of COVID-19 protocols that needed to be adhered to.

4.6. Conclusions

This study concludes that educators are not aware of the principle of knowledge integration when teaching natural sciences in grade 9. Knowledge integration of sub-disciplines of natural sciences could assist them into teaching natural sciences thematically without them carrying the heavy load that seems to be a challenge they face yearly. The principle of knowledge integration would assist them to tackle themes like “earth and beyond” using knowledge from Life Sciences, Geography and Physical Science adequately. This calls for educators who can integrate content knowledge from all natural sciences sub-disciplines using Web model or connected model as explored in the literature reviewed in this study. Furthermore, if educators are found wanting in content knowledge of various disciplines where such themes are required to be taught, they would find it difficult to prepare learners to excel in science disciplines offered in the Further Education and Training (FET) Phase curriculum. It is therefore imperative that educators are prepared to impart adequate knowledge required by the set curriculum to prepare learners to excel in the FET phase. From the findings of this study, it has become imperative that teachers should undergo training that will prepare them to educate learners to attain skills that will enable them to have a broader scope of disciplines and careers they can choose from when they leave secondary schooling.

Lack of resources as one of the findings of this study can be overcome by innovations that educators could venture in as they negotiate the impartation of all integrated disciplines in natural sciences. If the lack of disciplinary content knowledge was not an issue of concern to the educators, improvisation and use of technological skills that enact skills required for the Fourth Industrial Revolution (4IR) implementation at schools.

4.7. Recommendations

1. In-service training of the currently employed educators on how natural sciences can be taught using the principle of knowledge integration is required to assist educators in understanding that the content prescribed by the CAPS curriculum is possible and can alleviate the burden and pressure caused by viewing the subject as having a cumbersome load. This can be done through the application of Forgarty's models of knowledge integration to demonstrate the use of the thematic approach in the sequencing of curriculum.
2. As the custodians of the school curriculum, Curriculum Advisors need to be brought up to speed with challenges faced by educators at the school context. The sooner the Curriculum Advisor adopt models of knowledge integration in natural sciences, they will be empowered with skills needed for curriculum trimming that is made possible by adopting mode 2 teaching and learning skills which require the principle of knowledge integration. They will then be able to advise educators on how best they can cover the prescribed curriculum without resorting to teaching learners on topics that they will assess their learners.
3. Recently trained educators under the auspices of Minimum Requirements for Teacher Education Qualification (MRTEQ) (DHET, 2015), should be trained on how knowledge integration can be used as a tool for adequate teaching and learning of natural sciences as mode 2 learning (multidisciplinary teaching and learning) is stipulated as being key to training of preservice teachers.

4. Once educators are trained on how to adopt the principle of knowledge integration to teach natural sciences, they will be able to transition into integrating technologies into teaching and learning process. This will enable them to quickly transition into preparing learners for operating in the digital space through integration of ICT knowledge when teaching sciences. This will assist in overcoming the challenge of resource as experiments and other resources are available digitally.

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