Running head: The concept of 'basic secondary school science teacher knowledge': reforming science teacher education in Zimbabwe

Zimbabwean Teachers’ espoused and enacted knowledge for teaching Ordinary-Level Integrated Science

A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy

by

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Abstract

There is an on-going discourse on exploring Teacher Knowledge in General Education and Science Education fields (Elbaz, 1983; Shulman, 1987; Grossman, 1990; Carlsen, 1999; Lederman, 2006; Chapman, 2013; Goodwin & Kosnik, 2013). Central in this discourse on Teacher Knowledge is understanding teachers espoused and enacted knowledge, especially in the context of Developing Nations. This area of research is appropriate as Teacher Knowledge has a direct bearing on student success (Coleman, et al., 1966; Ferguson, 1991; Flippo, 2001; Reutzel & Cooter, 2012). Teacher Knowledge is by definition, embedded in the personal context of the teachers, where all kinds of domain-related, teacher-related and pupil-related and the intermingling of these circumstances play a role and for this reason Verloop, Driel, & Meijer (2001) stresses that it is logical to direct the search for shared Teacher Knowledge on groups of teachers that are in similar situations with respect to variables such as subject matter, level of education, and age group of students. This research interrogates the content of the Integrated Science teachers’ knowledge and how it manifests itself in teachers who have specialised in Chemistry, Biology or Physics during their pre-service teacher education. This study is guided and limited by the central question; “What basic Teacher Knowledge do Integrated Science teachers who specialised in Chemistry, Biology or Physics require for their teaching epistemic construction?” This question is further unravelled through two research questions: 1. How do teachers who specialised in Chemistry, Biology or Physics describe secondary school Integrated Science teaching? 2. What are the gaps in knowledge between the Integrated Science teachers’ espoused knowledge from teacher education institutions and the enacted experiential knowledge needed in Integrated Science classrooms?

This study followed a mixed methods research design with an initial quantitative phase in which 60 Integrated Science (IS) teachers were selected through snowball sampling and
surveyed. A purposive case selection of 9 IS teachers from the 60 teachers were then interviewed during the second research phase. The research participants were divided into 3 equal cohorts in both phases of the research according to area of study specialisation (Chemistry, Biology and Physics).

The results of the study indicate that the IS teachers have a common set of knowledge, skills, and dispositions that are, in their professional opinion, needed and in some instances, would enable them to teach IS. The research participants had considerable knowledge as well as clear views about what it meant for them to be IS teachers. The participating IS teachers provided insights into the challenges they encounter as they implement the IS curriculum and also proffered suggestions on teacher education curriculum improvement. A striking feature of the survey findings was the similitude in discernments among the three cohorts with different levels of teaching experience. It appears that when engaging in teaching of out-of-field concepts these experienced IS teachers, in many respects, depicted that they felt de-skilled and novice-like again in the classroom. The IS teachers from the Physics cohort were much more prone to this de-skilling. IS teachers who specialised in Chemistry education were found to be much more likely to accept as true that teaching through Practical Work is as important as teaching theory in IS than those who specialised in Physics Education. Despite the IS teachers resonating with the importance of Practical Work in teaching IS and being aware of the demands of the IS syllabus document, they however, indicated that there were massive challenges encountered when embarking to teach through Practical Work and most of them, especial those from the Physics cohort revealed that they did not expose their students to the practical and investigative approach pre-specified in the IS syllabus document. The research participants were generally in concurrence across the cohorts that students’ culture was essential for learning IS. Some Chemistry and Physics IS cohort teachers felt that their content
knowledge acted as a barrier to teaching IS. The broadness of the IS syllabus was reported as making the teachers rush-over as they teach in order to finish teaching in the prescribed time and hence sacrificing student learning. The teachers proffered changes to the IS syllabus where some concepts should be removed replacing them with other concepts. Most IS teachers (6) who participated in interviews reported that they did not find any bliss when teaching IS. Reasons given ranged from shallowness of IS content, little support offered by the schools, not being proficient in teaching some concepts outside-field-of-specialism, slow learners, students not being well motivated, resource constraints, little time allocated for IS on the time-table, to very high student to teacher ratio. The IS teachers’ areas of specialisation remained a major influence in the decision they made in the classroom, what they deemed as important in student learning was basically based on their area of specialisation. The research participants who specialised in Biology indicated that they felt better equipped for teaching IS upon graduation whilst at the far end those who specialised in Physics indicated that they needed some more years of experience, learning in the field, to be better teachers of IS. The Physics cohort teachers identified secondary and high school science subjects and professional courses as being an essential foundation for their teaching of IS, those who specialised in Chemistry referred to a few chemistry courses and professional courses, those from Biology education cohort indicated quite a number of courses which they took at college which aided them in the teaching of IS. The IS teachers recommended that teacher education curriculum should be reformed to integrate e-learning, put more emphasis on practical work, revise the teaching methodologies courses and avoid specialism when preparing teachers for IS teaching. The findings of this study unveil knowledge that seems to fall into the space made up of knowledge that is part of intended student learning as depicted in the syllabus document, of which knowledge the IS teachers are aware of, but of which the students are not exposed to due primarily to school situation in which the resources (chemicals, reagents, laboratory space and human resources)
are lacking and the teachers’ out-of-field of specialisation situation. Assuming that teaching well is a result of teachers being aware of the available pedagogical options; this study however indicate that the school situation plays a significant role on how the knowledge demanded of a teacher plays out in practice. For those teachers who find themselves teaching concepts out-of-field of specialisation the outplay of the demanded Teacher Knowledge goes well-beyond simply knowing the syllabus rules and how to manipulate them with fluency. When out-of-field of specialisation, teachers find comfort in engaging in teacher centred methods of teaching, whereby they resort to ‘theorising’. This study provides contextual inputs to effective IS teacher education re-alignment informed by the IS teacher practitioners, those with the craft knowledge of the contextual environment of the Zimbabwean IS classrooms. Ultimately, with the findings of this study, a tool for recruiting and developing teachers who can effectively teach IS can be developed.
Dedication

I dedicate this dissertation work to my family, friends and colleagues. I will always cherish their support.
Acknowledgments

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Chapter One
The problem and its settings

1.0 Preamble to the chapter

This chapter introduces this research through a discussion of the problem and its setting. In this chapter the contextual background of the study is established. A Statement of the Problem together with the Research Questions are posed and the chapter is then wrapped-up through a summary.

1.1 The contextual background to the study

Understanding the way in which teachers perceive the way they teach and how they should be teaching is central to current research on Teacher Knowledge (Shulman, 1987). Teacher Knowledge has been viewed under diverse epistemological conceptions which maybe congregated around three lenses; positivist/post-positivist, interpretivist, and critical theorist. These three lenses point on diverse truths about form and purpose of this knowledge (Calderhead, 1996; Tom & Valli, 1990; Cohen, Manion, & Morrison, 2018). Collectively, these epistemological conceptions expose an overview of how teacher knowledge has been investigated (Verloop, Driel, & Meijer, 2001).

The positivist lens view Teacher Knowledge as “a set of law-like generalizations” (Calderhead, 1996, p. 715), as “hard, objective and tangible” (Cohen, Manion, & Morrison, 2018, p. 5) and as knowledge identified in research and applied by teachers with a goal to improving teacher effectiveness. This positivist approach implies a normative philosophical stance. This stance assumes that a right Teacher Knowledge is objective and exist independently of teachers or those observing them (Scott & Usher, 2011; Cohen, Manion, & Morrison, 2018). According to Cohen, Manion, & Morrison (2018, p. 16),

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The positivist view of the world is of an ordered, controllable, predictable, standardized, mechanistic, deterministic, stable, objective, rational, impersonal, largely inflexible, closed system whose study yields immutable, absolute, universal laws and patterns of behaviour (a ‘grand narrative’, a ‘metanarrative’) and which can be studied straightforwardly through the empirical, observational means of the scientific method. It suggests that there are laws of cause and effect, often of a linear nature (a specific cause produces a predictable effect, a small cause (stimulus) produces a small effect (response) and a large cause produces a large effect), which can be understood typically through the application of the scientific method.

The positivist orientation of Teacher Knowledge is characterised by a theory-practice nexus where generalisations are advanced from arduous empirical studies which are methodically applied to classrooms in a context-free manner in order to improve student learning. These generalisations may be considered as guidelines for practice with anticipations of changing them along scientifically based prescriptions. Within a positivist framework, Teacher Knowledge can be reduced to “simple statements which can be objectively compared between individuals or against specified targets for learning” (Taber, 2013, p. 124). A starting point for the normative-positivistic approach is a teacher’s understanding of teaching, that is, the understanding that a teacher has acquired or being asked to acquire, and the teachers’ knowledge of teaching is in effect being measured against that. Taber (2013, p. 137), however, is of the view that, “It is becoming apparent that, realistically, no research report is likely to do full justice to an individual’s understanding, so all such reports will be simplifications and approximations” and any hypothetical authentic account of a teachers’ understanding of teaching will be a report of something which is complex.

On the other hand, the interpretivist/hermeneutic perspective or discourse analysis view knowledge as dependent on context and on the meanings attached to it by humans. Teacher Knowledge illuminated through this perspective is viewed as to be generated on a case-by-case basis where context is exceptionally vital, and teachers develop personal, practical
theories about teaching and learning (Tom & Valli, 1990). Research on Teacher Knowledge based on interpretivist approach often take an eclectic methodology (Janík, Najvar, Slavík, & Trna, 2009) through case studies or ethnographies that are interpreted by teachers in the context of their own classrooms thus revealing meaning within contexts. The interpretivist approach to Teacher Knowledge research is “rooted in a social constructivist paradigm in which behaviours and their meanings are socially situated and socially interpreted” (Cohen, Manion, & Morrison, 2018, p.694). Janík, Najvar, Slavík, & Trna (2009, p. 51) clarifies that methods grounded on the observation of teaching pose only a limited understanding of the Teacher Knowledge, “as this is an inner construct which can only be gathered to a limited extent from its external manifestations. It is therefore necessary to ask the teachers questions – examine their articulation of the knowledge”.

On the other end critical theory paradigm of science education like interpretivist approach is context dependant, but, it however has as its hallmarks in conjecture and refutation and the ability for falsification and transformation being the distinguishing features (Cohen, Manion, & Morrison, 2018). According to (Kincheloe, 1995, p. 55) critical theory is an attempt

to rethink the meaning of human self-direction or emancipation, to develop a theory of non-dogmatic social transformation, to expose the hidden social relationships of the everyday world, and to analyse the problems of social theories that celebrated social harmony without questioning the assumptions of the larger society.

Critical theory provides a powerful case for the acknowledgement and elucidation of Teachers Knowledge in light of institutional and ideological constraints (Barnett & Hodson, 2001), as well, knowledge, within the realms of critical theory is considered as observer-dependent and is bloated with multiple realities. These diverse realities are valued
different within a society. Knowledge in light of critical theory serve specific interests and characterise certain power relations which assists in revealing how certain values are prevented from being articulated or esteemed (Calderhead, 1996; Tom & Valli, 1990). Critical theory’s main purpose is to provide teachers with means of analysis, which explain how critical theory alters teachers’ interpretations of themselves and their teaching and has an effect of validating hegemony (Kincheloe, 1995) through recognition of oppression. Critical theory seeks to expose the interests at play in school work stations, to cross-examine the legitimacy of those concerns as well as identifying the extent to which they are authentic in serving equality and democracy (Cohen, Manion, & Morrison, 2018). For critical theorists, educational practices are often pervaded with xenophobic, chauvinistic, and class predispositions, critical theory therefore is destined to be used to change, modify, and restructure educational practices so that they become fair for all involved (Grimmett & MacKinnon, 1992; Ladson-Billings, 1996, 1999).

These three broad philosophical perspectives of Teacher Knowledge generate their own idiosyncratic sets of assumptions and lexicons of terminology. Critical theory regards the positivism and interpretivism worldviews as presenting incomplete accounts of social behaviour when they neglect the political and ideological contexts of educational research (Cohen, Manion, & Morrison, 2018). The positivistic perspective is preoccupied with technical knowledge whilst interpretive paradigm is seen concerned more with hermeneutic knowledge.

Although Teacher Knowledge research may be situated within the three perspectives, Teacher Knowledge and its research is a complex construct and process. “An understanding of the specific knowledge that science teachers are expected to have in order
to become proficient in science teaching is still sparse” (Wang, nd). Teachers’ workplace learning and its contribution to experienced teachers’ professional learning is a very under-researched area in science education (Childs & McNicholl, 2007). Furthermore, the categorisation of this Teacher Knowledge remains a contested area in terms of it being generated from empirical work or in its ability to provide a theoretical framework (Childs & McNicholl, 2007). And still, Schueler, Roesken-Winter, Jochen, Lambert, & Matthias (2015, p. 3) highlights another dimension of Teacher Knowledge, “the issue of out-of-field-teaching is undertheorised and underresearched in reference to crucial aspects that characterise out-of-field-teachers’ professional knowledge and practices”. Most of the research on teacher learning converge around changes in the knowledge that teachers acquire. There is a direct focus on knowledge construction and organisation in this type of research while of recent, efforts are being employed to situate this knowledge in the teachers’ local practice, i.e. the classroom and the society in which a particular teaching and learning situation occurs (Scardamalia & Bereiter, 2006; Bronwen, 2010; Keast & Cooper, 2011; Tan, 2014). The evolution of research on Teacher Knowledge help in situating perspective of this research. This research is more inclined within the interpretivist perspective. Research on Teacher Knowledge is of utmost importance as it has a direct bearing on student success (Ferguson, 1991; Flippo, 2001; Reutzel & Cooter, 2012).

1.2 Statement of the Problem

This research examines the correlation between teacher education experiences and secondary school praxis that Integrated Science teachers who have specialised in Biology, Chemistry or Physics at college attribute to their Integrated Science teaching epistemic construction. It is hoped that such an examination might act as a basis for secondary school
science teacher education institutions in Zimbabwe to better design the science teacher education curriculum and also to some extent as an estimation of the efficacy of science teacher education system. It is worth pointing out that neither generalizable truths about the knowledge of the Integrated Science teachers in Zimbabwe nor judgements or evaluation of their knowledge is being sought in this study. These two goals are elusive due to the focus of this study and the numerous intervening variables which results in teaching being a complex process, and also due to sometimes divergent standards of what is good teaching and what knowledge is required to carry out this extremely contextualized course of action. Instead, what is being interrogated is the content of the Integrated Science teachers’ knowledge and how it manifests itself in teachers who have specialised in Chemistry, Biology or Physics during their pre-service teacher education.

1.3 Research Questions

This research is initial guided and limited by the central question, “What teacher knowledge does Integrated Science teachers who specialised in Chemistry, Biology or Physics require for their teaching epistemic construction?” Specific aspects of teacher knowledge typologies are examined basing on supporting questions that are generated after a close reading of extant relevant literature (Elbaz, 1983, Shulman, 1987, Grossman, 1990; Carlsen, 1999; Lederman, 2006; Corrigan, Dillon, & Gunstone, 2011; Chapman, 2013; Goodwin & Kosnik, 2013). The following research questions are put forward as guidelines for this inquiry. These supporting questions are aimed at collecting data that support inferences about the nature of Integrated Science Teacher Knowledge.

1. How do teachers who specialised in Chemistry, Biology or Physics describe secondary school Integrated Science teaching?
2. What are the gaps in knowledge between the Integrated Science teachers’ espoused knowledge from teacher education institutions and the enacted experiential knowledge needed in Integrated Science classrooms?

1.4 Outline of the chapters

This study provided an opportunity for an interpretation of the Integrated Science teachers’ knowledge and how it manifests itself in teachers who have specialised in Chemistry, Biology or Physics during their pre-service teacher education. Researching teachers’ trepidations as they navigate the enacted IS curriculum with their students, vis-à-vis the espoused curriculum, can help determine which areas the teachers continue to struggle with and help provide guidance on improving teacher education programmes.

Chapter One described the context for this research through identifying the positivist, interpretivist and critical theory as the three principal lenses through which Teacher Knowledge might be understood. The chapter further presented the research problem and questions that guide it. The next chapter, Chapter Two, provides a theoretical framing for this study and reviews scholarly literature related to Integrated Science curriculum and Teacher Knowledge. The review of related literature is synchronised around: rationale for an Integrated Curriculum; arguments on knowledge types; conceptions about the nature of Teacher Knowledge; and the ecology of science teaching/ Teaching outside one’s specialism. The main purpose of this literature review was to inform the methodology of choice for this study. Some analytic questions guided this review of literature and assisted to sharpen-in on specific topics that were deemed most relevant to this study. Chapter Three describes the methodological issues with regard to the conduct of this study through
detailing the research setting, role of the researcher, the participants, and data-collection methods used in this study, ethical considerations, the quantitative and qualitative data analysis procedures employed, as well as, assumptions and limitations of this study. The research findings are presented in Chapter Four. Data from the questionnaire which contained Likert-scale statements where the research participants delineated their views and perceptions with their levels of agreement or disagreement and responses to Section C of the questionnaire instrument’s open-ended, short-answer questions are presented. The ‘semi-structured interview’ which had as intention to further understand commonalities of the participants’ perceptions of and experiences with Integrated Science Teacher Knowledge construction, and, at the same time, examining the unique, individual differences of these teachers is also presented in this chapter. Chapter Five discusses findings in relation to the relevant literature, consider implications of the findings and articulate directions for further research.
Chapter Two
Theoretical Framework and Review of Related Literature

2.0 Introduction

This chapter describes the theoretical basis of this study as well as examining scholarly literature related to Teacher Knowledge and Integrated Science curriculum. Five major sub-headings framed the review of scholarly literature. These sub-headings are: (a) Arguments on knowledge types; (b) Conceptions about the nature of Teacher Knowledge; (c) Rationale for an Integrated Curriculum (d) Teaching outside one’s specialism and (e) a summary of the review. The aim of this review was to inform the methodology of choice, inform the analysis and discussion of findings of this study.

Germane literature for this review was identified through development of analytic questions to guide the review. As Teacher Knowledge and Integrated Science topic areas have a broad scope, the analytic questions were developed in order to sharpen in on specific topics that were thought to be most relevant to this study. Database and Google searches were conducted to identify theoretical and empirical literature for the review. Some of the databases searched using various search terms included but were not exclusive to: Google Scholar, ERIC, Springer, Springer Link, ProQuest, and Tandf. Books, particularly those consisting of articles and chapters reviewing empirical or theoretical scholarship in the field of Teacher Knowledge, Knowledge, Curriculum, Specialism and Integrated Science Curriculum contributed immeasurably to this review. This chapter serves as a review report of a synthesis of several studies that addressed these different issues.
2.1 Theoretical framework

Choosing a theoretical framework allowed for the determination of theories and models to guide this research and also assisted in connecting the findings to these theories and in so doing helped with the analysis and explanation of the results. The theoretical framework targeted Teacher Knowledge in its entirety as it is presented in keystone researches in the past three decades. The use of the Teacher Knowledge theoretical framework in this study was meant to mirror the existing breadth of Teacher Knowledge as inclusive of but not limited to a teacher’s understanding of specific content that is taught. In so doing the research is framed under the theoretical perspective of Teacher Knowledge. The research depends upon an epistemological perspective as central to understanding of teaching (Strom, 2000). In this framework, teaching is principally an epistemological endeavour. Bullock (2011) aptly posits that the fundamental tension in any contemplation of teachers’ knowledge is one of epistemology, particularly between the epistemologies of propositional knowledge and practical/experiential knowledge. Munby, Russell, & Martin (2001) view teaching as depending upon and is stuck in and is knowledge. Teacher Knowledge has been defined as, 'a framework for helping prospective and experienced teachers develop their repertoire of responses, understandings, and magical tricks” (Grimmert & MacKinnon, 1992, p. 441). This seems to mean that Science Teacher Knowledge may help in addressing what is fundamental for teaching science basing on facts, information, principles and skills acquired by an educator through experience and/or education (Abell, 2007; Verloop, Driel, & Meijer, 2001). It is the theoretical and practical understanding of science instruction and science classroom practice. Teacher Knowledge therefore is the universe of knowledge about situational, conceptual, procedural and strategic knowledge (de Jong & Ferguson-Hessler, 1996) that a science educator may possess during her/his professional life.
Several research efforts have been made towards identifying the knowledge teachers should learn, teacher educators should teach and teachers have (Shulman, 1987; Verloop, Driel, & Meijer, 2001; Adoniou, 2015). The nature of Teacher Knowledge debates often borders on whether Teacher Knowledge is situated within contexts or is propositional in nature (Calderhead, 1996). Teacher Knowledge research has traditionally been conducted outside of the classroom in which teachers use their knowledge. Moves have been made towards conducting studies of Teacher Knowledge in classrooms. Elbaz (1983) was one of the pioneers to locate Teacher Knowledge within the confines of a school (context and culture) and indicated that this enacted knowledge and the school situation definition of Teacher Knowledge influences the way teachers make instructional decisions and what their students learn. In order to gain insight into Teacher Knowledge, which Elbaz (1983) referred to as "practical knowledge", she studied an English language teacher she called "Sarah" in a Canadian high school over a two-year period. This study described Sarah’s practical knowledge from several overlapping perspectives: content, orientation, and structure (Elbaz-Luwisch & Orland-Barak, 2013). Elbaz (1983, p. 5), indicated that whilst Teacher Knowledge might be largely unarticulated, teachers do possess a broad range of knowledge which guide their work, this “situated knowledge encompasses first-hand experience of student's learning styles, interests, needs, strengths and difficulties, and a repertoire of instructional techniques and classroom management skills." She organised this knowledge into five heuristic groupings; which are knowledge of (i) self, (ii) the milieu of teaching, (iii) subject matter, (iv) curriculum development, and (v) instruction.

Elbaz (1983, pp. 132, 133, 137) contends that the teacher practical knowledge is represented in practice in three ways: First as rules of practice, through "brief, clearly
formulated statements of what to do or how to do it in a particular situation”; second, as practical principles, "more inclusive and less explicit formulations in which the teacher's purposes ... are more clearly evident"; and third, as images, which in the case of Sarah are defined as "a brief, descriptive, and sometimes metaphoric statement which seems to capture some essential aspect of Sarah's perception of herself, her teaching, her situation in the classroom or her subject matter, which serves to organize her knowledge in the relevant areas".

Elbaz (1983) sought to grasp Teacher Knowledge eccentrically through narratives without imposing a theoretical framework for the research. She found out that what Sarah knows is not propositional knowledge ‘Epistêmê’ (Gr.), but how to perform instructional tasks, resolve conflicts, adjudicate competing considerations, and connect ambitions to plans and then to instructional performance. Elbaz (1983) contends that these understandings make up Sarah's ‘technê’ (Gr.) "practical knowledge."

Whilst Elbaz (1983) view Teacher Knowledge as practical knowledge, to some degree tacit and descriptive, Shulman (1986; 1987) to the contrary put forward a more normatively/prescriptive oriented structural analysis of Teacher Knowledge. It is hinged on what Teacher Knowledge should be, i.e., the espoused knowledge. Shulman (1986)’s analysis distinguishes three categories of Teacher Knowledge: subject matter knowledge; pedagogical knowledge and curricular knowledge. In a later article which broadened the categories of Teacher Knowledge, Shulman (1987, p.5) posit “the knowledge base of teaching” concept in order to characterize the components of knowledge domains for effective teachers. The author pinpoints to seven categories of the knowledge bases for effective teaching: (i) content knowledge, (ii) pedagogical knowledge, (iii) curricular
knowledge, (iv) pedagogical content knowledge (PCK), (v) knowledge of students, (vi) knowledge of educational context, and (vii) knowledge of educational outcomes. PCK is given a special place as according to Shulman (1987), it is the unique knowledge for teachers which enable them to deliver a successful lesson. These domains of Teacher Knowledge can be divided into general teacher knowledge and content related teacher knowledge.

**Figure 1**

*Shulman (1987)'s Knowledge bases of teaching*

General pedagogical knowledge are the broad principles and stratagems of classroom management and organisation that appear to go beyond a specific content (Shulman, 1987). Although Shulman (1987) acknowledged the importance of this knowledge domain, he however bemoaned that there has been an over emphasis on this domain at the detriment of knowledge of the content knowledge.
The content knowledge domain corresponds to important ideas (facts, concepts & principles) and skills in a subject domain (Substantive knowledge). It also encompasses how neoteric notions are added and deficient ones dropped by those who produce knowledge in the subject domain [syntactic knowledge] which Shulman (1987, p. 9) referred to as knowledge of the “historical and philosophical scholarship on the nature of knowledge” in a discipline. Content knowledge therefore is the substantive and syntactic structures of a knowledge discipline (Grossman et al., 1989). It is the subject matter which the teacher holds. Shulman (1986, p. 9) argued that a teacher should become a subject matter expert, fully proficient in the content of the disciplines taught, “not only understand that something is so… [but correspondingly] why it is so”.

The curriculum knowledge domain corresponds to the materials and programs that serve as “tools of the trade” for teachers (Shulman, 1986, p. 10). According to Shulman (1986), teachers should be in possession of both the lateral and vertical curriculum knowledge. Lateral curriculum knowledge encompasses knowledge of the curriculum materials to which students being taught by a particular teacher are exposed to, from other subject areas, other than the one the teacher is currently teaching. Vertical curriculum knowledge is that knowledge of a particular subject area, e.g. Integrated Science, that was taught or will be taught in the years prior to and posterior to the current school year.

PCK is presented as “the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of the learners, and presented for instruction” (Shulman, 1987, p. 8). It is being knowledgeable about how to epitomise the content of a discipline in ways that
help others learn it. Shulman (1987, p. 9) highlighted that PCK is uniquely a jurisdiction of teachers, their own special form of “professional understanding into how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction”. These representations include “analogies, illustrations, examples, explanations, and demonstrations” (Shulman, 1986, p. 9). PCK distinguishes science teachers from mere scientists. Shulman (1987, p. 15) said,

We expect a math major to understand mathematics or a history specialist to comprehend history. But the key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students.

This quotation elucidates that, not only should a science teacher be a content area specialist, but should respond aptly, and in a timely way, to the variables of diverse student needs, curricular organisation, and classroom context and should know what instructional methods are better suited for teaching a specific science concept to varied and unique groups of students (Grossman, 1990; Shulman, 1987).

In his explanations of various knowledge types, Shulman (1987) was cautious not to trivialise teaching through ignoring its complexities. Several knowledge types that went yonder the subject matter and pedagogical skills were included, such areas as students’ psychological and physical traits and the purposes of education. Knowledge of learners and their characteristics fall under this category and entails cognitions on how students learn, their learning styles, and their motivation to learn. A teacher’s knowledge of the students’ characteristics enable catering for different needs of learners and can prevent teaching from become too standardized.
Knowledge of educational contexts or practice looks at the milieu of teaching “ranging from the classroom dynamics and governance, financing of schools, to the character of communities, cultures” and values (Shulman, 1987, p. 8). It is knowledge of the bigger picture surrounding the classroom. Knowledge of educational contexts assist teachers through informing them about how a community may perceive their educational actions. The development of PCK is shaped by the teachers’ understanding of the social, political, cultural, and physical environmental contexts (Cochran, DeRuiter, & King, 1993).

Knowledge of educational purposes, values and their philosophical and historical grounds is cognition of educational ends. Teaching activities are purposeful and teachers construct their values of educational ends within a social-moral framework.

Shulman’s domains of Teacher Knowledge have been metamorphosed by researchers in several ways, some empirical and some theoretical. For example, Grossman (1990) a student of Shulman, categorised Teacher Knowledge into discrete domains similar to Shulman (1987). Grossman (1990) tributes Shulman’s work in the late 1980s with helping to shift research on Teacher Knowledge away from behaviourist approaches and toward cognitive approaches. Grossman (1990, p. 5) coalesced Shulman’s knowledge of learners with general pedagogical knowledge and added knowledge of curriculum and educational purposes to PCK to form four general areas of Teacher Knowledge. These she listed as the cornerstones of the emerging work on professional knowledge for teaching: general pedagogical knowledge, subject matter knowledge, pedagogical content knowledge, and knowledge of context: general pedagogical knowledge, subject matter knowledge, pedagogical content knowledge, and knowledge of context.

On researching English teachers’ Pedagogical Content Knowledge, Grossman expanded and refined Shulman’s (1987) PCK focusing on four distinct components of PCK (Grossman, 1990, pp. 8-9):

1. Knowledge of the goals for teaching a subject at various grade levels.
2. Knowledge of the conceptions and misconceptions students are likely to have about a subject at a given grade level.
3. Knowledge of the curriculum of a subject at various grade levels and the curricular materials available to enact the curriculum.
4. Knowledge of instructional strategies, metaphors, and images for teaching particular topics within a given subject.

These four components of PCK are heuristic divisions and when teachers’ classroom practice is considered they are intertwined. Grossman (1990) asserted that a bidirectional nexus exists between PCK and other parts of Teacher Knowledge. Grossman (1990) acknowledged the highly situational nature of teachers’ environments but asserted that context is not a major source of teachers’ Pedagogical Content Knowledge (Bullock, 2011). Grossman identified sources from which teachers develop PCK: their experiences as students in elementary and secondary school (i.e., their prior knowledge through apprenticeship of observation), their pre-service teacher education programs, and their experiences in the classroom. Although Grossman (1990, p. 15) acknowledges the role of professional experience in developing Pedagogical Content Knowledge, she clearly viewed propositional knowledge as a necessary precursor to experience: “Teaching experience provides the opportunity for prospective teachers to test the knowledge they have acquired from other sources in the crucible of the classroom”.

Carlsen (1999) explicates that Shulman’s descriptions of Teacher Knowledge and its application draw very heavily on Schwab (1964)’s structures of the (traditional) disciplines. This disciplinary approach according to Carlsen (1999) addresses two problems simultaneously: one, the problem of how to define Teacher Knowledge in ways that are valuable in research and two, the problem how to make teaching a career choice more prestigious and rewarding. The author noted that these two problems are still relevant, but the conceptions of knowledge that inform them need to be updated (Carlsen, 1999). Carlsen (1999) embraces a post-structural interpretation through criticising scholars
who attempted to identify the make-up of Teacher Knowledge as assuming a structural view. He articulated that these structuralist models of Teacher Knowledge view knowledge as fixed and systematic and hence exhibit a naïve approach to power and knowledge relationships and thus fail to represent the historical and cultural aspect of knowledge. Whilst acknowledging the structural weaknesses of Shulman’s structural perspectives, Carlsen propound that the two fundamental issues in teaching (the problem of definition of Teacher Knowledge in ways that are useful in research and the problem of making teaching a more prestigious and rewarding career choice) can be resolved without a major overhaul of Shulman’s original formulation of the domains of Teacher Knowledge and hence propose the expansion of Shulman (1987)’s Teacher Knowledge base into the domains of Teacher Knowledge shown in figure 2 as presented graphical by Carlsen (1999).

**Figure 2**

![Diagram showing Carlsen (1999, p. 136)'s Domains of teacher knowledge](image-url)
The typifying feature of Carlsen (1999)’s post-structural model of Teacher Knowledge is that although knowledge domains are separate from each other, they are however defined by reciprocal relationships with each other.

All these models and many more others which have been left out offer insights into Teacher Knowledge. Like Carlsen (1999) states, models of Teacher Knowledge vary according to knowledge categories. It however should be re-emphasised that Teacher Knowledge is by definition, embedded in the personal contexts of the teachers, where all kinds of domain-related, teacher-related and pupil related circumstances play a role and for this reason Verloop, Driel, & Meijer (2001) stresses that it makes sense to direct the search for shared Teacher Knowledge on groups of teachers that are in similar situations with respect to variables such as subject matter, level of education, and age group of students. It would be prudent to search for shared components of Teacher Knowledge and strive for “certain overarching generalizable features which are common across teachers” (Brown & McIntyre, 1993, p. 19).

With this evident upsurge of research in knowledge bases for science teaching (Elbaz, 1983, Shulman, 1987, Grossman, 1990; Carlsen, 1999; Lederman, 2006; Corrigan, Dillon, & Gunstone, 2011; Chapman, 2013; Goodwin & Kosnik, 2013) questions about the exact nature of Teacher Knowledge and what teachers need to know are recurring in contemporary research. These questions “continue to plague teacher education, teacher assessment, and teacher practice” (Fives & Buehl, 2008, p. 13). These pronounced developments in teacher education research are however mostly pronounced in the Western world and are to a greater extent attributed to an emphasis towards a standards-based approach on quality of science teaching (Corrigan, Dillon, & Gunstone, 2011).
Zimbabwe as a developing country is also catching up on this impetus with calls for the full professionalization of the teaching fraternity through establishing a Teaching Service Commission and a Teaching Profession Council for standards control, self-regulation and discipline of members (Majongwe, 2013). With this in mind it is only prudent to continue interrogating on Teacher Knowledge especial for the knowledge for teaching of Integrated Science as it is taught by teachers who have specialised in particular science disciplines like Chemistry, Biology or Physics.

Although Teacher Knowledge studies in general education and science education field (Elbaz, 1983, Shulman, 1987, Grossman, 1990; Carlsen, 1999; Lederman, 2006; Chapman, 2013; Goodwin & Kosnik, 2013) have made significant exposé in furthering understanding of Teacher Knowledge, there is, however still scarcity of research on science teacher education in developing nations and still very little have been done to analyse and explain the knowledge base of teachers who have specialised in Biology, Chemistry or Physics but are teaching Integrated Science. Whilst there is much agreement about the value of Teacher Knowledge, there is however impassioned analysis and debate on how Teacher Knowledge is organised and used (Kennedy, 2002; Munby, Russell & Martin, 2001). The question of what type of knowledge is needed for teaching (Wilson, Shulman, & Richert, 1987) and, in particular, teaching Integrated Science is pertinent. Even more compelling is the question of how this knowledge could be used to inform secondary school science teacher education program design. Designing teacher education programs basing on Teacher Knowledge might assist beginning teachers to construct understanding of the subject matter that differs from that of subject matter experts (i.e. biologist, chemist, or educational researchers), not in eminence or magnitude, but in how the subject matter aids student’s understanding.
The articulation of Teacher Knowledge assemblages as featured in these various research programs (Shulman, 1987; Grossman, 1990; Carlsen, 1999) should ultimately be considered to be heuristic in nature, and thus they should be seen as outlines for investigation rather than actual mental structures (Borko & Putnam, 1996). The use of Teacher Knowledge base assemblages in this study is meant to reflect both the existing breadth of Teacher Knowledge for teaching Integrated Science, as well as the importance of conceptualizing Teacher Knowledge as inclusive of but not limited to a teacher’s understanding of the specific content that is taught. With these considerations on cognition in mind, this research is guided principally by the works of Elbaz (1983), Shulman (1986, 1987), Grossman (1990), and Carlsen (1999) to analyse the basic secondary school science teacher knowledge in Zimbabwe.

### 2.2 Arguments on knowledge types

A school curriculum is viewed axiomatically as a choice from an array of cognitions, skills or dispositions that are available within a society which have or are being exhibited in practices of a conversational, official, agential or personified kind (Scott, 2014). When a curriculum is being constructed choices are always made on the nexus of cognitions, skills and dispositions of the curriculum contents, its pedagogic forms, its learning strategies, and its evaluative criteria and apparatus. These choices require some justification/rationale for the chosen curricular contents. This rationale, according to Scott (2014, p. 15),

> can take an epistemic form: a curriculum is in essence a framework for some type of learning or another; learning whether cognitive, skill-based or dispositional is understood as a knowledge-development activity; and therefore, knowledge is central to the construction and realisation of the curriculum.

As Philosophers continue grappling with what knowledge is (Muis & Gierus, 2014), the process of curriculum making or curriculum analysis should therefore, determine the form
or kind of this knowledge, and how it is formed and legitimated. Knowledge development is facilitated through learning and there is need for its conceptualisation as it is a currency in educational struggles and debates.

Upon dismantling the concept knowledge, Fieser (2011) reveals three key elements to knowledge. These are truth of a claim, personal belief conviction for a claim and, evidence or justification that is there for a claim (Fieser, 2011). Basing on these three key elements, knowledge has been defined as justified true belief [JTB-tripartite theory] (Fieser, 2011). Despite this definition being considered a practical contemporary working archetype of what knowledge is, it however is not tight proof as it is often affected by ‘The Gettier Problem’ whereby some situations might be justified true belief, but not counting as knowledge, for example, illusions (Fieser, 2011). The closest rival to defining knowledge as justified true belief is infallibilism. Infallibilism suggests that knowledge, is when there is absolute certainty and when knowledge cannot be rationally doubted, as opposed to belief or opinion which is rationally justified without absolute certainty, casting some doubt (Fieser, 2011).

Knowledge has been considered as a duality. Dualities of knowledge types is replete in literature, such dualities are; formal/practical (Fenstermacher, 1994), propositional/procedural (Russell & Munby, 1991), and technical/craft (Schon, 1983). Brennan (2002) traces back to the time of Aristotle the duality of knowledge where ‘episteme’ referred to worldly knowledge held with a high level of confidence (knowing facts about something), knowing-that, and ‘techne’ referred to knowing how to do something, knowing-how. Collins (2014, p. 11) citing Ryle indicates that “Knowing-how cannot be reduced to declarative statements about the world”. The knowing-how are
abilities or sensorimotor skills which are developed through intuitive as well as trial and error learning or imitative apprenticeship to some master craftsman (Collins, 2014) and this, has also been referred to as procedural knowledge (Russell & Munby, 1991).

Knowledge dualities are confounding, overlap and suffer varied interpretations. What is identified by one author as “theoretically” another one terms this “propositional” and whilst one author refers to “practical” knowledge another one terms this “Procedural” knowledge. Borko & Putnam (1996, p. 677) forewarn;

A potential danger inherent in any description of categories of knowledge is that people may come to see the categories as representing an actual storage system in the human mind rather than a heuristic device for helping us thing about teacher knowledge. That is, we may find ourself thinking that teacher knowledge is organised into abstract, isolated, discrete categories whereas, infact, what teachers know and believe is completely intertwined, both among domains and within actions and context.

In viewing Knowledge as a dichotomy, Conklin (1996) explicates informal and formal knowledge. Formal knowledge is that which is codified in books, manuals and documents, and which can be easily shared in education courses, whilst informal knowledge is the knowledge that is applied in the process of creating formal knowledge (Conklin, 1996).

There has, however, been disputation of knowledge as a dichotomy. Leonard & Sensiper (1998) view knowledge as a continuum on a spectrum in which one extreme is totally tacit (i.e. subjective experiential, unconscious and semi conscious) knowledge held in originators’ heads and body, whilst on the other extreme end it is totally explicit or codified, structured (objective and rational) knowledge and accessible to people other than its originators. Leonard & Sensiper (1998) make a claim that most knowledge exist between these two extremes. Their disputations are
however of little import as they identify and coin two knowledge types (tacit and explicit) on the extremes without exactly identifying the other knowledge types along these two ends or the exact gradations between these extremes.

Belief is another issue on knowledge which has attracted a lot of debate. Liljedahl (nd) posit that distinguishing between knowledge and beliefs is a false dichotomy. Leatham (2006, p. 92) enunciates this dispute precisely:

> Of all the things we believe, there are some things that we "just believe" and other things we "more than believe – we know." Those things we "more than believe" we refer to as knowledge and those things we "just believe" we refer to as beliefs. Thus beliefs and knowledge can profitably be viewed as complementary subsets of the things we believe.

Individuals’ actions are steered by beliefs rather than what may or may not actually be true (Liljedahl, nd). IS teachers are thus no different, their teaching is steered through what they believe as good teaching. As such, any deliberations on Teacher knowledge, is about deliberations on teachers justified true beliefs (Fieser, 2011).

### 2.3 Conceptions about the nature of Teacher Knowledge

Teacher education research has taken a multi-prong thrust in recent years as education researchers show growing interest on the concept ‘Teacher Knowledge’. Some of the directions followed by this research include; what teacher knowledge is, what it should be, how it is developed, the nature of its relation to student and school success and how the teachers perceive teacher knowledge (Smaller, 2012) and how is it researched.

The conception of Teacher Knowledge has been in constant change, contestation and development over the past thirty years (Blomeke & Delaney, 2012) and along the way sometimes assuming on considerable ambiguity. A number of terms have been put
forward such as ‘knowledge base of teaching’, ‘teacher cognition’, ‘professional knowledge for teachers’, ‘teacher decision-making’ and ‘teacher learning’. Blomeke & Delaney (2012) traces the development of the concept Teacher Knowledge through these decades by pinpointing that Teacher Knowledge research was initiated in early 1980s through the study of ‘teacher learning’- defined as a process of reflection and action in which teachers develop skills, and acquire knowledge and expertise (Billett, 2001). These studies were mainly targeting ‘learning by observation’, ‘learning by planning, application and reflection’ and ‘teacher learning as a craft’. This phase was followed by the mid 1980s and 1990s thrust where the focus was placed on the ‘cognitive basis of teachers’ pedagogical practices’. Of recent teacher education research and practicing teachers research is focusing even more strongly on the ‘knowledge base of teachers’ classroom practice’.

Through a study of fourteen teachers in their initial year of teaching English literacy in Australia, Adoniou (2015) provided a framework for describing the complexity of Teacher Knowledge and viewed Teacher Knowledge as a complex tapestry in which teachers “must successfully weave the multiple threads”, whereby the expectations are that a teacher should know a great deal, in numerous areas and in multiple ways. Adoniou (2015, p. 99) presented “three ways of knowing: ‘knowing how’, ‘knowing why’, and ‘knowing what’ ” as discourses of knowledge which was then applied across six domains of Teacher knowledge. These six domains of Teacher Knowledge are not discrete or isolated, but are connected and situated within the settings teachers work in and grow with reference to their motivations and to these contexts. These six domains are:
• **Knowledge about content**- Content knowledge is accepted truths in a domain or discipline along with a discernment of why propositions are held to be reasonable, why they are worth knowing, and how they link up to other propositions (Shulman, 1987). Shulman (1986) emphasizes that inadequate content knowledge by the teacher leads to constricted and regressionist pedagogies as teachers resort to replicating own past experiences which may result in teachers providing “inadvertently confusing instruction” to students (Spear-Swerling & Cheesman, 2012, p. 1692).

• **Knowledge about theory**- All practice should be informed by theory, and an articulate and solid theoretical foundation is necessary for building positive learning and teaching experiences (Adoniou, 2015). Although contradicting theoretical positions often impact upon the pedagogical choices teachers make, theoretical knowledge is however a crucial thread in the Teacher Knowledge tapestry (Adoniou, 2015).

• **Knowledge about teaching**- Shulman (1986) identified Pedagogical Knowledge as broad principles of classroom management that transcend subject matter and Pedagogical Content Knowledge as knowledge about the teachability of content and how to make it understandable to students: an amalgam of content and pedagogy. Pedagogical Knowledge and PCK make up knowledge about teaching.

• **Knowledge about their learners**- Good teachers should know their learners and successfully identify their Zone of Proximal Development in order to plan effective lessons because learning needs differ according to the learners’ cognitive development as well as their environmental context (Adoniou,
2015). The environmental context influence how students learn and consequently how teachers should teach.

- **Knowledge about school context** - Teacher experience is shaped by school context (Gu & Day, 2011) and this school context which is the community in which a school is situated, define the way teachers “plan, report, assess, and administer” their teaching (Adoniou, 2015, p. 103).

- **Knowledge about the sociocultural politics of teaching** - Teaching is always politically fraught. Although schools have their own micro-sociocultural politics often than not national educational directives not only change the face of teaching, they are “changing what it means to be a teacher” (Adoniou, 2015).

On the other hand Alexander, Schallert, & Hare (1991 p. 317) define teacher knowledge as “an individual’s personal stock of information, skills, experiences, beliefs, and memories related to the practice and profession of teaching”. By including ‘beliefs’ in defining Teacher Knowledge, Alexander, Schallert, & Hare (1991) has demonstrated that discussions of teachers' knowledge cannot be strictly limited to only objective forms, i.e. knowing-what and knowing-how but also to teachers' subjective knowledge (Liljedahl, nd). "It has become an accepted view that it is the teacher's subjective school-related knowledge that determines for the most part what happens in the classroom" (Chapman O. , 2002, p. 177). A pivotal aspect of this ‘subjective knowledge’ is beliefs (Op ’T Eynde, De Corte, & Verschaffel, 2002). Researchers have long posited teacher beliefs as important factors in teachers’ knowledge development (Bandura, 1986; Kagan, 1990; Pajares, 1992). Pajares (1992, p. 19) argues, “knowledge and beliefs are inextricably intertwined .... The potent, affective, evaluative, and episodic nature of beliefs makes them a filter through which new
phenomena are interpreted”. Beliefs about teaching may develop not only from a teachers’ classroom experience or received knowledge but may also herald and shape these. These beliefs may be assimilated from many years of classroom exposure as a student and such beliefs might be flawed. As teachers come to teacher education they do not come as blank slates, believing that they know nothing about teaching (Liljedahl, nd), but long before they start a teacher education programme they would have developed a network of interrelated ideas about teaching and learning, and about schools (Ball D., 1988). These beliefs are often the basis on which teachers build their practice.

Fuller & Brown (1975) categorised Teacher Knowledge development into four stages. These stages are:

- **First stage**- student teachers identify realistically with students but not with teachers.
- **Second stage**- teachers are worried about classroom contexts survival: they are concerned with classroom management, subject matter knowledge, and adequacy in fulfilling the role of a teacher.
- **Third stage**- in this phase teachers self-evaluate their instruction performance (reflects).
- **Forth stage**- the academic, social, and emotional needs of students is the major concern of the teacher.

Berliner (2004) on the other hand put forward five stages on how teachers may become experts. These stages are novice, advanced beginner, competent, proficient, and expert. This linear model may be considered faulty as a teacher may be a novice in teaching one concept and at the same time being proficient in teaching another. Another dimension on discussing the development of Teacher Knowledge is that of Maxwell (2010, p. 4) who posits that the “objectivist epistemology, where knowledge is fixed and external to the teacher and socio-cultural conceptualisation, where knowledge that
is provisional, fluid” and “contested is constructed through participation in social practices as approaches to conceptualising teacher professional knowledge”.

Teacher Knowledge research has been conducted employing varied research instruments and designs, these include: questionnaire surveys, document analysis, semi-structured interviews, qualitative designs, quantitative designs and mixed methods research, case studies with the aim of eliciting both qualitative and quantitative data (Chen & Goh, 2014; Maxwell, 2010). Quantitative studies on Teacher Knowledge have generally examined Teacher Knowledge through a positivist/post-positivist epistemological lens (Tom & Valli, 1990) and of recent quantitative methods such as surveys have been employed to research teachers’ technological pedagogical content knowledge (e.g. Erdogan & Sahin, 2010; Sahin, 2011; Schimidt, et al., 2009). On conducting a methodological analysis of teacher knowledge research Chen & Goh (2014) observes that small-scale qualitative studies feature strongly in literature where interviews and case studies offering rich and in-depth discernments into the complexities and specifics of the knowledge of selected small groups of teachers. These small scale qualitative studies however do not generalise the findings to teachers even those in the same context (Chen & Goh, 2014).

2.4 Rationale for an Integrated Curriculum

What is an Integrated Curriculum? Why implement an Integrated Science Curriculum? These analytic questions guide this section. Venville & Dawson (2004, p. 148) allude to the difficulties in answering such questions due to multiplicity of Integrated curriculum approaches. Venville & Dawson (2004) proposed that the key tenets of an Integrated Curriculum should include; research based on several discipline
areas, flexible timetables, team teaching, student-centred learning and high levels of interaction among students, between students and teachers and among teachers. Integrated Science is an example of an Integrated Curriculum. Integrated Science teaching accentuates the structural unity of science and leads towards a comprehension of the place of science in modern-day society (Chisman, 1990). An Integrated Science Curriculum (ISC) may be considered therefore as blend of knowledge from different science disciplines; an approach to learning and teaching from an assortment of world-views, strategies, and resources; and the taking advantage of real-life situations for problem solving and critical thinking in the classroom (Harrell, 2010). Integrated Science assumes as pivotal, the significance of observation for augmented understanding of the environment: it initiates pupils to logical thinking and scientific method (Chisman, 1990). Edstrom, Gunnarsson, & Gustafsson (2007, p. 79) defines an Integrated Curriculum as a “curriculum designed with mutually supporting disciplinary courses, with an explicit plan to integrate personal and interpersonal skills, and product, process, and system building skills”. Edström, Gunnarsson, & Gustafsson (2007, p. 78) characterised Integrated Curriculum as systematic approach with the following important attributes:

- It is organized around the disciplines. However, the curriculum is re-tasked so that the disciplines are shown to be more connected and mutually supporting, in contrast to being separate and isolated.
- The personal and interpersonal skills, and product, process, and system building skills are highly interwoven into mutually supporting subjects, relieving the potential tension between science disciplines and these skills.
- Every learning experience sets specific learning outcomes in disciplinary knowledge, in personal and interpersonal skills, and in product, process and system building skills, to ensure that students acquire the appropriate foundation for their futures as scientifically knowledgeable citizens.

Harrell (2010) believes that all Integrated Curricula have as an underlying theoretical base a strong root in Gestalt psychology. Gestalt psychology examines the learner as
an organic whole and strive to engage the individual in focused learning experiences that are purposeful and meaningful (Benjafield, 1996).

Grant and Paige (2007) articulates that, “Teachers and researchers do not know all the answers to questions about the advantages and disadvantages of Integrated Science teaching practice and the consequence in terms of student learning”. Chisman (1990, p. 15) enumerated the trends and forces influencing Integrated Science as:

a) persistent attempts to introduce science into the primary school curriculum;
b) the widespread acceptance that integration of science at lower secondary level should be part and parcel of general education;
c) increasing attention being given to the training of teachers for integrated science;
d) the inclusion of social issues, especially environmental issues, in secondary school science curriculum as a deliberate attempt to relate science teaching to social concerns;
e) the need to arouse scientific curiosity in students in schools and to develop a positive attitude towards science;
f) recognition of the existence of children’s science before the students are exposed to science in schools. The ideas and concepts held by children - gained from a variety of external sources, including parents, the media, etc - are firmly held and cannot be so easily changed or diverted into traditional subject disciplines.

Chisman (1990) forewarns that any approaches to Integrated Science have to take into account these outlined trends and forces.

According to Tytler (2004), Integrated Curriculum approach provides interconnections, and juxtapositions that may detain a student’s resourcefulness and enable the student to toil in preferred areas of interest and style whilst encouraging a broader perspective. Edstrom, Gunnarsson, & Gustafsson (2007) sums-up the rationale for introducing an Integrated Curriculum in two aspects: Practical reasons and Pedagogical reasons. Practical and pedagogical reasons often form a basis for constructing an Integrated Curriculum (Edstrom, Gunnarsson, & Gustafsson, 2007).
Practical reasons are often employed when it becomes clear that it is not possible to have the time nor the resources for an additional course into the curriculum. It therefore becomes practical to make a twofold use of time and resources within disciplinary courses, capitalising on the synergy of the simultaneous learning of professional skills and disciplinary knowledge (Edstrom, Gunnarsson, & Gustafsson, 2007). On the other hand, pedagogical reasons sprout from psychological reasons for such a curriculum decision. Theories of learning can best be used in examining the psychological influences of curriculum. These theories of learning are classified into three expansive categories such as: Behavioural learning, cognitive and developmental and humanistic learning theories.

Malloy (1996, p. 233) concluded that “curriculum is a potent tool for reform when it integrates and interrelates subjects and disciplines in a manner that makes learning experiences meaningful”. When a curriculum is being reformed, it is tricky to add more content or time, especially if the intended learning outcomes are beyond the disciplinary core content. Time and resources have to be dual made use of when re/constructing a curriculum within disciplinary science subjects already available, making use of the synergy of the simultaneous learning of skills and disciplinary outcomes. It becomes impractical and difficult to continuously add new science subjects into the curriculum because the average student’s class load per school term will become full. The pedagogical rationale for an Integrated curriculum is encountered when a teacher demonstrates personal, interpersonal, product, process and system building skills, in such a way that students have opportunities to develop these through Integrated Science activities (Edstrom, Gunnarsson, & Gustafsson, 2007). Personal and interpersonal skills, and product, process, and system building
skills are learned and practiced in specific contexts. Jucker (2004) and Capra (2002) explicate that the content of learning should in nature be inter-disciplinary and systems thinking so as to promote sustainability on local, regional and global economy, cultural and environmental issues. Jucker (2004) argues that in teaching and learning specialisation should be asphyxiated and all aspects of a topic should be laid bare on the go. This according Jucker (2004, p. 16) means:

We will make mistakes, we find it difficult because we are unaccustomed to thinking in systems- we shouldn’t be afraid of making fools of ourselves because we need to get better at looking at the whole story- our survival depends on it.

Similarly, Capra (2000) argues for the need of a new way of conceptualising the world, and an innovative way of thinking, that is thinking in terms of relationships, connectedness and context. The strategies that are encouraged for stimulating students’ intellectual quality and connectedness, which are two aspects of ‘productive pedagogies’ are for the teachers to be connected with students’ life worlds, integrating knowledge bodies and using rich tasks as a foundation for curriculum planning (Hattam & Prosser, 2006).

Knudsen (1937) had earlier-on identified the conditions for implementation of an Integrated Science Curriculum as being the availability of very able teachers, a wide and rich selection of materials, and an administration which is friendly to innovation and experimentation. These conditions are however often elusive due to a number of challenges which are often encountered when implementing an Integrated Curriculum. These challenges range from: severe teacher shortages especial in the sciences departments (Harrell, 2010), unsupportive administration, to insufficient prerequisite background knowledge of teachers needed to implement the curriculum which may result in poor development of student knowledge (Palmer, 1991). Werner (1991)
warns that conflict when teaching an Integrated Curriculum may erupt as a result of teachers’ sense of Content Knowledge expertise if these teachers are teaching outside their area of specialism. Harrell (2010) advises that a teacher’s content knowledge is an important factor which should considered when aiming for an effective implementation of an Integrated Curriculum.

Integrated Science curriculum has been passionately critiqued for “unfounded, unsubstantiated, or both” conclusions often being advocated for as more effective than good teaching of a traditional curriculum (George, 1996). George (1996) contrary to Hattam & Prosser (2006) advices that little evidence exists to show that an Integrated Curriculum is any better than good teaching of a traditional curriculum. Gardner cited in Hatch (1998, p. 19) argue that each discipline/subject operates under fundamentally different ways of knowing and that ‘robust understandings of important phenomena and concepts depend on the study of disciplines’. His advice was

Integrated Curriculum advocates continue to clarify the meaning of the term; conduct and publish credible research on Integrated Curriculum results; and realize and appreciate the dedication and commitment of the thousands of educators not yet persuaded about wholesale, immediate Integrated Curriculum adoption.

Although at a first glimpse, this may appear to be a savage assault on Integrated Curriculum, however, Hatch (1998)’s views admonishment might be considered as a bidding for teachers and school authorities to comprehend more thoroughly this approach and to judiciously study it.

Literature is replete with a multiplicity of curriculum integration modes. Badley (1986) described four modes of curriculum integration and these are: fusion, incorporation, correlation, and harmonization. According to Badley (1986) fusion
entails joining together at least two separate disciplines. Badley (1986) goes on to exemplify fusion as when physical science joins together the disciplines of physics and chemistry. Incorporation is when one curriculum element is added or is absorbed (Badley, 1986). For example, a unit on organic chemical bonding is added to the biology curriculum. On the other hand, an example of correlation is when connections are made between separately taught subjects, such as the timing of the study of biomes in world geography and biology so as to overlap. This mode of integration can be done through thematic units. Disparate curricular elements that are compatible can be united through harmonization (Badley, 1986). An example of harmonization can be teaching critical thinking skills across the curriculum. Having reviewed some of the modes of curriculum integration it becomes prudent to now refer to the Integrated Science Curriculum in Zimbabwe.

Zimbabwe Schools Examinations Council (ZIMSEC) inherited the Ordinary Level Integrated Science (IS) syllabus from the University of Cambridge in 1998, when the Zimbabwean government finally struck a deal to localise all its high school certificate examinations (Hove, et al., 2011). As preamble to the ZIMSEC Ordinary Level IS syllabus aims are presented seeking to meet the needs of candidates whose formal study of Science may cease at the end of ‘O’ Level and advises those wishing to pursue studying sciences at A-Level to opt for either the Physical Science (Zimbabwe) ‘O’ Level or the Biology (Zimbabwe) ‘O’ Level course, or both. IS is a terminal subject and this by implication means that Integrated Science is meant to meet the students’ science literacy needs only. Of interest is the syllabus aim # 12 which states that IS aims to help pupils to participate in the technological development of Zimbabwe; this seems to be a contradiction to the intended focus of only a science literate citizen.
(ZIMSEC, 2010). The recommended methodology of teaching the Integrated Science curriculum is through pupil centred problem-solving approach which include practical work, individual and group work, integrated, co-ordinated, topic-based approach or any other style of organisation and delivery whilst discouraging memorisation (ZIMSEC, 2010). The ordinary level Integrated Science syllabus has five (5) distinct compulsory topics that have different levels of difficulty. These are Science in industry, Science in energy uses, Science in agriculture, Science in structures and mechanical systems and Science in the community. About a third, in terms of content and time, of the Integrated Science curriculum is dedicated to Science in agriculture and Science in the community which have a strong bias to Biological sciences. It appears as if the construction of the IS curriculum followed Badley (1986)’s harmonisation and fusion modes of curriculum integration.

2.5 Teaching outside one’s specialism

The word specialism has been defined as ‘the subject knowledge gained by a teacher through their degree studies and/or employment outside of teaching (i.e. industry)” (SCORE - Science Community Representing Education, 2011). Out-of-field teaching is phenomenon whereby a teacher is expected to teach a subject or year-level outside his or her field of qualification or expertise (du Plessis, 2017). Teaching out-of-field has been described as “education’s dirty little secret” in the 1990s. According to du Plessis (2017),

Out-of-field teaching is not an aberration, and it is not restricted to only a few subjects—for example, to the STEM-subject areas of Science, Technology, Engineering and Mathematics—but has implications for all subject areas and year level.

Out-of-field teaching phenomenon is usual a consequence of incessant curriculum changes and transformation of subject fields which oblige teachers to teach subjects
for which they have neither the necessary qualifications nor expertise (du Plessis, 2017). This phenomenon of teaching arises due to a number of motives such as: teacher supply/demand imbalances (teacher shortages), the manner in which teachers are employed and utilised (school leadership and management making decisions based on budgetary constraints rather than what is needed by departments), teacher choice, and alternative curriculum models where teachers should teach in cross-disciplinary teams (Ingersoll, 2002; Hobbs, 2013). An emaciated research base about the scope of this phenomenon strongly varies across different countries, educational systems and school types (Schueler, Roesken-Winter, Jochen, Lambert, & Matthias, 2015).

When taking teachers’ professional knowledge as a reference frame, out-of-field-teachers seem less qualified in a particular teaching subject than teachers that were especially trained to teach that subject regarding content knowledge and pedagogical content knowledge (Schueler, Roesken-Winter, Jochen, Lambert, & Matthias, 2015). The insufficient content knowledge held by such teachers induce lower self-efficacy-as a result of disrupted teacher identity, their level of interaction during their teaching is drastically reduced- compromised teaching competence, and this often impede student learning (Hobbs, 2013; Nixon & Luft, 2015). Out-of-field-teaching is often associated with teacher strain and attrition (Ingersoll, 2002). It also places additional strain on subject coordinators/heads of departments and school administrators due to the extra support, mentoring and resources needed (Taylor, 2000). Childs & McNicholl (2007, pp. 8-11) enumerate the issues and challenges science teachers face in teaching outside subject specialism as:

- Selecting suitable and effective strategies and resources to promote learning, including details of technical practical work and various ‘tricks of the trade’.
- Ability to select key points to emphasise and elaborate in a lesson and how to build up scientific concepts over the longer term.
- Teacher explanations of scientific concepts and identifying and dispelling student misconceptions.
- Rigid, unimaginative teaching
- Effect of teaching outside subject specialism on student motivation and learning.

These issues and challenges point to the pivotal influence of teachers’ knowledge base which permeates all aspects of teaching like preparation, planning and decision making concerning the choice of content to be learnt (de Jong, Veal, & van Driel, 2002).

Out-of-field teachers appear in two forms in literature (Nixon & Luft, 2015). The first type is those that are in a subject area completely different from what their college major or minor was, e.g. a biology teacher teaching mathematics, the second type are those that teach within a multi-disciplinary field, such as Integrated Science e.g. a physics teacher teaching a Science in Agriculture section of Integrated Science (Nixon & Luft, 2015) as is the case with some of the teachers in this study.

Researches about teachers teaching science topics within and outside their areas of specialism emphasize the important differences in the quality of preparation and delivery of science lessons. Hashweh (1987)’s research with six experienced secondary school teachers preparing to teach topics within and outside their area of expertise show pronounced differences in planning, response to students’ questions and lesson development based on their prior content knowledge. Within-field-of-expertise teachers are robust, more confident, being able to draw links between different areas of knowledge in the same subject, modifying and expanding students’ activities whilst teachers teaching outside subject specialism tend to be rigid, less
confident, in their teaching following a textbook structure quite closely and tend to ask recall questions (Mizzi, 2013).

2.6 Summary

This chapter presented a review of scholarly literature related to science Teacher Knowledge. The four sections presented in the review are; arguments on knowledge types, nature of science teacher knowledge, rationale for an Integrated Curriculum and teaching outside one’s specialism. The research cited in the review suggested that Teacher Knowledge is a very broad construct, with multiple definitions and conceptualizations. It is presented in literature as being made up of different forms and types of knowledge which are categorised around knowledge about content, knowledge about teaching, knowledge about learners, knowledge about school contexts and knowledge about sociocultural politics of teaching. Most of the literature reviewed show that these knowledge categories are important in the teaching and learning of Integrated Science. Teachers teaching Integrated Science most times teach some topics out of their specialism, of which, most times as is revealed in literature present some issues and challenges. This review provides a foundation for this study’s focus. The next chapter, Chapter 3 describes the research methodology followed in this research.
3.0 Introduction

This chapter discusses the methodology utilized to explore the Teacher Knowledge of IS teachers. The chapter is initiated through an outlay of a reflexivity statement which describes the role of the researcher in this research and the probable researcher related limitations. This is followed by a description of the research design. Then a description of the research setting, the participants, and data-collection methods used in this study ensues. The construction and administration of the tools to collect qualitative and quantitative data are also described. This is followed by a description of the quantitative and qualitative data analysis procedures. Ethical considerations guiding the research and its limitations and assumptions are then discussed. The chapter is skirted by a summary.

Although the research questions were stated earlier on, they are presented here at the start of this chapter to inform the discussion of the current chapter. This study is guided by the following research questions:

1. How do teachers who specialised in Chemistry, Biology or Physics describe secondary school Integrated Science teaching?

2. What are the gaps in knowledge between the Integrated Science teachers’ espoused knowledge from teacher education institutions and the enacted experiential knowledge needed in Integrated Science classrooms?
3.1 Reflexivity Statement

The role of a researcher is a factor for consideration in Teacher Knowledge research (Chapman, 2013). The researcher in this study was a graduate student pursuing a doctorate in the field of science education. The researcher has a licentiate in education degree in Biology, a graduate degree in curriculum studies and was an IS and Biology teacher for nine years in public middle and high schools. At the time of the study, the researcher had been a Bindura University of Science Education lecturer in the Faculty of Science Education for seven years. The researcher’s interest arose as a result of working as a science teacher and teacher educator. The researcher’s interests stem from a belief that there is need for understanding how to provide prospective and beginning science teachers with the best possible tools and knowledge to have successful and productive teaching careers. The researcher’s professional career had positioned him in close contact with science teachers and their communities of practice for which this study targeted.

This author acted as a sole researcher in this study. The author as a sole researcher with assistance from the PhD advisory committee designed the research, determined which data was to be collected, collected the data, managed and protected the data, analysed the data, explained the data, and reported the findings (Borland, 2001). The author created a theoretical framework, which was the basis for data collection, through embarking on review of related literature. The researcher was personally involved in the study through deciding when to apply the instruments and to whom; deciding who to interview and when, and what to record during data collection and hence relied on his feelings, impressions and judgement in data collecting (Gall, Borg, & Gall, 1996).
The researcher first conducted a preliminary review of related literature, through which a theoretical framework was created to base data collection. The research instruments were then designed and approval was granted by the PhD advisory committee. Permission for the administration of research instruments and conducting of the research was sought and granted by the Permanent Secretary in the Ministry of Primary and Secondary Education of Zimbabwe.

A mixed-methods research that addressed the demands of the theoretical framework was written by the researcher. A section of the questionnaire following a Likert-scale survey design was the principal research instrument guiding the quantitative part of the research (Carifio & Perla, 2008; Likert, 1932). The enhancement of the understanding of participants’ experiences was sought through a second section of the questionnaire that utilised the qualitative component of short-answer questions. These open-ended questions allowed the participants to support and expand their responses to the Likert statements, helping the researcher to develop a holistic view of their experiences (Marshall & Rossman, 2011). Direct interviewing of nine Integrated Science Teachers who were selected from a compliment of those who had responded to the questionnaire followed the application of the survey.

As the research progressed, the researcher reflected on his own values, assumptions, beliefs, and bias and this process of reflection was maintained throughout the study so as to limit researcher bias on the study’s data and interpretations (Mertens, 2005). The researcher sought guidance of the PhD advisory committee throughout this research.
The researcher may have judged teachers’ knowledge based on what he believed IS teachers’ knowledge should look like being subtly influenced by his educational and professional background. As the study progressed, the researcher came across some teachers whose knowledge and practice aligned with how he believed IS should be taught, as well, there were others whose knowledge and practice reflected totally different views. This may have swayed the researcher to frame the research findings from the qualitative phase of the study to concur more with those teachers whose knowledge and practice seemed to align with those of the researcher. Additionally, due to the researcher’s beliefs about best practices for teaching IS, the researcher may have instinctively arbitrated teachers in a negative way if their knowledge or practice aligned with other philosophies.

In order to minimise the effect of these potential biases, reflexivity (Merriam, 2009) was used. The researcher detailed the research experiences and potential biases in memos as the qualitative phase of the research was underway, explaining how some assumptions and beliefs may have shaped the way particular interpretation of data was arrived at (Merriam, 2009). Also, data collection and analysis strategies and decision-making processes to explain how results were arrived at was logged. Furthermore, interviews were consciously carried-out in such a manner as to try and avoid conveyance of any potential unconscious judgment of teachers’ knowledge or practice.

### 3.2 Research Design

This research employs sequential explanatory mixed methods design which is one of the most popular mixed methods designs in educational research (Creswell J. W., 2013). This mixed methods design consists of two distinct phases (Creswell,
Tashakkori, Jensen, & Shapley, 2003). The sequential explanatory mixed methods design has an initial quantitative phase resulting in a case selection followed by a qualitative phase. Figure 3 provides a graphical representation of the mixed methodology data collection and analyses processes.

**Figure 3**

As indicated by Figure (3), a mixed methods approach informed the research findings. Teddlie & Tashakkori (2009) defines the methodology of mixed methods as an inquiry which is broad and has as purpose to steer the choosing of specific methods being informed by conceptual positions held by mixed methods practitioners like rejecting the ‘either-or’ stance throughout all levels of the research approach. For Teddlie & Tashakkori (2009) such a pragmatic definition of a research methodology differentiate the mixed methods approach from that conducted under the umbrellas of qualitative or quantitative approaches. Creswell & Plano Clark (2007) proffered an extended
definition for mixed methodology research whereby they defined it as a research design possessing a philosophical assumptions and methods of inquiry. Mixed methods research can also act as a methodology whereby its philosophical assumptions shepherd the route for data collection and analysis and the blending of qualitative and quantitative approaches in all research process phases (Creswell & Plano Clark, 2007). Creswell & Plano Clark (2007) goes on to say that, mixed methods research as a method, emphasizes on gathering, analysing, and blending both quantitative and qualitative data into a single study or series of studies. The central premise of mixed methods research is that of using quantitative and qualitative approaches as an amalgam to provide a better comprehension of research problems than can be proffered by either approach alone (Creswell & Plano Clark, 2007). Johnson & Onwuegbuzi (2004, p. 14) further elucidate that mixed methods research has as its ‘key feature methodological pluralism or eclecticism, which frequently results in superior research (compared to mono-method research)’. According to Denscombe (2008, p. 272) mixed methods can:

a) increase the accuracy of data; b) provide a more complete picture of the phenomenon under study than would be yielded by a single approach, thereby overcoming the weaknesses of single approaches; and c) enable the researcher to develop the analysis and build on the original data.

Besides, a mixed-method approach allows triangulation of the methods and cross-validation of the data. Verloop, Driel, & Meijer (2001, p. 452) exposes the benefits of a mixed methods approach in Teacher Knowledge research by saying:

By means of multi-method triangulation, it is possible to cover not only the well-considered aspects of teacher knowledge, which are relatively stable and can be put into words rather easily, but also the ephemeral aspects. The aim is to enhance the internal validity of the research.

This study researched on the Integrated Science teachers’ knowledge. Given the complexity of teachers’ knowledge (Adoniou, 2015; Taber, 2013), Kagan (1990), argues that it can only be researched and captured using more than a single instrument.
In this regard, data for this research was therefore gathered from multiple sources using the questionnaire (with a structured and open-ended parts) and interviews. This study began with an examination of literature on Teacher Knowledge, then there was the designing of an Integrated Science Teacher knowledge questionnaire which was followed by the administration of the questionnaire. The qualitative evidence from the open-ended questions on the questionnaire and the quantitative evidence obtained from the statistical analysis of the first part of the questionnaire enriched the design and informed the administration of the Integrated Science teaching interviews. Thus, the qualitative evidence originated from multiple sources. Both quantitative and qualitative evidence informed the research findings report. Quantitative data made an important contribution to the building up of the information base of the study. A more in-depth understanding was gained from qualitative data. These methods explored causal factors associated, provided reasons for various actions, and revealed socio-cultural influences. They, thus, made the interpretation of the data more meaningful. The data collected using the questionnaire and interviews was complementary and formed a more complete and comprehensible picture of the final research findings.

This design is suitable for research on Integrated science teachers espoused and enacted knowledge because of the need not only to investigate the participants' theoretical and practical understanding of science instruction and science classroom practice, but also to explore the different understandings and interpretations which the teachers bring with them to the situation.

The link between research question, research phase, data source and purpose for undertaking the particular research phase is tabulated in Table 1.
In Table 1, the first research question is primarily addressed by the first phase of the research whilst the second research question features in both the first and the second phases of the research.

### 3.3 Setting of the Research

In Zimbabwe “teachers are the single, most important component in the Zimbabwean education system. They are also the only measure parents, students, and administrators have for evaluating the effectiveness of the school system. Teachers have been institutionalised in the education system and remain the focal point of all curricular and classroom organisation” Makwati (2000, p. 1). Makwati (2000) goes on to observe that
the policy makers, planners, administrators, parents, and other stakeholders are greatly concerned about the quality of teachers deployed in the schools. This observation adds onto justifications for studies into Teacher Knowledge in Zimbabwe.

Pre-service science teacher education is conducted primarily through universities and teacher training colleges in Zimbabwe. The teacher training colleges are credited to the University of Zimbabwe whilst other universities offer autonomous programmes, they independently decide their teacher education curriculum. Although of recent university programs have to be accredited by Zimbabwe Council of Higher and Tertiary Education (ZimCHE) science teacher education programmes which have been in existence before inception of ZimCHE did not pass through this rigor. On the other hand, the school science curriculum is determined principally by the Ministry of Primary and Secondary Education after broad consultations. The students' summative (final) assessment and evaluation (award of certification at the end of Form four) is the responsibility of an independent examining board, the Zimbabwe School Examinations Council (ZimSEC).

This study focuses on Teacher Knowledge which is crucial in the teaching of Integrated Science at Ordinary level (Forms 3 and 4) in Zimbabwe. In 1996, the government of Zimbabwe, through the Curriculum Development Unit (CDU) and ZIMSEC, launched an O-Level Integrated Science Syllabus 5006 as a replacement of a Core Science syllabus (Vhurumuku, Holtman, Mikalsen, & Kolstø, 2008).

Integrated Science is one of the five compulsory subjects which every student should learn at Ordinary Level. The other subjects being English Language, a Vernacular Language mostly (Shona/Ndebele), Mathematics and History (UNESCO, 2010). At
Ordinary Level depending on the school’s resources, students are at liberty to enrol in other sciences in addition to Integrated Science such as: biology, chemistry, physics, human and social biology, physical science (chemistry, physics), science (physics, biology), and science (chemistry, biology) depending on them being on offer at a particular school station and also in most cases on the student’s prior performance in science.

“Examinations pass rates is one of the indicators of quality education in Zimbabwe” (Zimbabwe, 2008, p. 9). Student have not been performing very well in IS in ZIMSEC examinations at ordinary level. An analysis of November Ordinary Level examination results confirms that the performance students in IS was general low as compared to other science subjects, for example in year 2014 IS pass rate was 21.9%, 2015 was 31.52% and in 2016 it was 39.58% across Zimbabwe (Zimbabwe School Examinations Council, 2016). Comparing the 2016 pass rate with other Science subjects, whilst IS was 39.58% Physics was 61.18%, Biology was 57.07% and Chemistry pass rate was 77%. The number of formal students who sat for these examinations were; IS had 151 717 candidates, Biology had 23 138 candidates, Physics had 6 767 candidates and Chemistry had 6 842 candidates (Zimbabwe School Examinations Council, 2016).

3.4 Research Participants

The research participants are Integrated Science teachers in Zimbabwean secondary schools who specialised in Chemistry, Biology or Physics education at college. The detailed profiling of the research participants is in next Chapter.
3.4.1 Gaining Access to Participants

Prior to the study, permission to conduct the research was sought from the Permanent Secretary in the Ministry of Primary and Secondary Education of Zimbabwe (Appendix C). The researcher was awarded a letter of introduction by the Permanent Secretary and this letter was endorsed by the Provincial Education Directors. The endorsed letter was then taken to concerned School Heads who then granted the permission to apply the research instruments. Informed consent was then sought from the research participants before applying the instrument.

3.4.2 Selection of Research Participants

In order to understand Zimbabwean secondary school Integrated Science teachers’ knowledge, participants for this study were selected basing on four criteria: a) being graduate science teachers, b) experienced teachers (more than two years of Integrated Science teaching experience), c) currently teaching Integrated Science, and d) having specialised in Chemistry, Biology or Physics at college.

The 1st phase of the research followed a snowball or chain referral sampling technique whereby the Integrated Science teachers who have specialised in a particular discipline (Chemistry, Biology or Physics education) are identified and enrolled, and these then recruit future participants from among their acquaintances (Cohen, Manion, & Morrison, 2018). The snowball sampling technique was used because it was hard to establish a sampling frame as the data for science teacher’s specialisation and whether they are currently teaching Integrated Science or not could only be located at school levels. The spatial distribution of secondary schools in Zimbabwe is wide and some schools do not have a qualified science teacher. A lot of time would have been spent
(Handcock & Gile, 2011) on trying to locate the teachers who specialised in Chemistry, Biology or Physics but are teaching Integrated Science. So, the chain referral sampling technique was the most pragmatic and convenient way of sampling as well as including the participants into the research process. This resulted in the selection sixty Integrated Science teachers. These Integrated Science teachers were aggregated according to their specialisation i.e., Physics, Biology or Chemistry where by each specialisation was represented by twenty (20) teachers. This sample size was also recommended by the PhD advisory committee.

**Figure 4**

![Bar chart showing teacher specialisation among 60 Integrated Science teachers](image)

*Teacher Participants for Quantitative Data Evidence (N= 60)*

Of the sixty IS teachers who participated in the first phase of the research, nine were purposively selected for the interview phase of the research. This phase had as purpose to gain insight into the quantitative findings through an examination of the experiences of interview participants. In this second phase data were collected via one-on-one, semi-structured interviews with purposefully selected participants who had completed the questionnaire. For the qualitative research phase, the informants that provided more
detailed answers on the free-response section of the questionnaire and those with some vague answers which needed further probing, as well as having indicated willingness to continue participating in the research were purposefully selected, hence it was not necessary to select a sample randomly (Creswell, 1994). Pseudonyms with T-for teacher, a number and a letter referring to specialisation (T#C, T#B, T#P) were used throughout the study in order to maintain the confidentiality of the participants.

The number of participants for the 2nd phase of this research was also determined at a point when new data added little to the already discovered concepts, their properties and dimensions, as well as the relationships around the core concept. It was a subjective end point where a new theory was considered to be grounded in the data (Thomson, 2010). Additional participants were thus interviewed until all emerging categories reached saturation. This phase of the research reached theoretical saturation when all emerging categories were saturated. This is in-line with Thomson (2010; p. 49) who says “researchers cannot make a judgment regarding sample size until they are involved in data collection and analysis…they must allow the data to dictate the sample size”. Thomson (2010; p. 50) proposed a theoretical saturation occurring at “between 10 and 30 interviews”. Thomson (2010), however, does not elucidate whether the interview range requires unique individuals for each interview or if this interview range can include multiple interviews with fewer than ten to 30 participants. The number of participants in this research was determined through the concept of theoretical saturation. The data dictated the sample size.
3.5 Data Collection and Research Instruments

The data collection methods are presented in detail in this section to ensure the trustworthiness of both the process and the evidence. Two data collection methods are used in this study to collect quantitative and qualitative data to answer the research questions. These methods are: a questionnaire and an interview. The triangulation of the questionnaire and interview forms of data was one way to improve the confidence in reporting the findings (Hatch, 2002). Beginning with the questionnaire survey phase allowed participants to become familiar and comfortable with the research process and with the researcher’s presence (Hatch, 2002).

3.5.1 Integrated Science teacher knowledge questionnaire

The researcher created an ‘Integrated science teacher knowledge questionnaire’ aimed at ascertaining experienced science teachers' views of what constitutes the science teachers’ knowledge and as well, the challenges they face in their practice. As per the recommendations of Check & Schutt (2012, p. 162), the development of the survey was,

guided by a clear conception of the research problem . . . and the population to be sampled… The questionnaire [was] viewed as an integrated whole, in which each section and every question serve a clear purpose related to the study’s objective and each section complements other sections.

The questionnaire also acted as a foundation for the formulation and conduction of the second phase of the research, the interviews.

The “Integrated Science Teacher knowledge questionnaire” was designed to be self-administered and is divided into three sections (A, B and C). The first section, section A, seeks Science Teachers’ demographic data, that is, name (optional), gender, qualifications including area of subject matter specialisation, years of teaching
experience, school and level (forms) taught, subjects being taught. Section A assisted in the description of the study sample. The profiling of teachers is important in Teacher Knowledge research as this facilitate in deriving meaning of their situational and overall their conceptual, procedural and strategic knowledge through understanding their ‘Self’ (Elbaz, 1983; de Jong, Veal, & van Driel, 2002) as well as being able to infer the collected data to the IS teachers’ field of specialisation (du Plessis, 2017).

Section B interrogates the Science Teacher Knowledge through a 5-point Likert Scale, which made up of questions asking around Integrated Science teachers’ general teaching context and Subject matter related knowledge. The general teaching context knowledge covers education aims and school context, whilst the subject matter related knowledge is concerned with subject matter, curricular and Pedagogic Content Knowledge (Elbaz,1983; Shulman, 1986; 1987, Grossman, 1990 & Carlsen,1999).

The last section, section C of the questionnaire is free-response which request the participants to be more liberal in commenting on science Teacher Knowledge. The research participants were also requested to write contact details if so willing, so as to participate in the other phase of the research. The questionnaire ends with thanking the respondent for completing the questionnaire (see appendix A).

The questionnaire instrument embraced the different dimensions of Teacher Knowledge (Elbaz,1983; Shulman, 1986, Grossman, 1990 & Carlsen,1999). It closely matched the theoretical framework about different types of Teacher Knowledge as it encompassed the practical and propositional knowledge that IS teachers expressed (Elbaz,1983; Shulman, 1986).
3.5.2 Semi-structured interview protocol

A semi-structured interview was applied to during the second phase of the research. Cohen, Manion, & Morrison (2011, p. 236) clarifies a semi-structured interview as a schedule that is “sufficiently open ended to enable the contents to be reordered, digressions and expansions made, new avenues included and further probing undertaken”. This type of interview was used in this study as it allowed flexibility to explore issues that arose germane to the research questions and to probe further on those issues which were raised earlier-on or during the administration of the questionnaire. The interview questions were constructed to be short, easy to understand, and allow for expanded responses from the participant.

The Interview protocol design consisted of one-on-one semi-structured interviews of nine teachers who had participated in the first phase of data collection and volunteered to participate in the qualitative phase. Questions elicited a deeper understanding of the selected participants’ responses to the questionnaire items. A narrative to explain the quantitative findings was created through these interviews.

The form of the interview was informed through coalescing Seidman’s (2013) three-interview series into one 27 to 45-minute interview composed of three parts being mindful of teacher participants’ time and school/teaching schedules. Whilst the structure of Seidman (2013)’s three-interview series is such that in the first interview the context of the participant’s experiences is established through a focus on one’s life history; in the second interview the participants are lead within the context of present experience to reconstruct the details of their experiences; and the final interview demands the participants to reflect upon the meaning of their experience, the approach
in this research was giving much emphasis on what the IS teachers preferred to discuss about their lived experiences during their interviews. It should however, be noted that the need to direct the interviewees towards topics that were relevant to the research questions lingered in the back of the researcher’s mind and hence the interview guide. The interview data was analysed inductively following Merriam’s (2009) constant comparative method. The interview protocol was semi-structured which permitted for a fusion of structured, standard questions (i.e., the same questions were asked to all interviewees) and informal questions (i.e., the questions were custom-made to individual Integrated Science teachers based upon their questionnaire responses). The standard interview questions appear as Appendix B.

3.5.2.1 Interview description

Each one of the nine interviews were conducted in a semi-private ‘interview room’ which in some instances was the Integrated Science teacher’s office, laboratory or apparatus and reagents’ store room. The door into the interview room was closed during the interviews.

The semi-structured interview protocol (Appendix B) directed each interview, and supplementary questions were asked of some interviewees when appropriate. The semi-structured interviews commenced with questions based on a broad area of experience, continuing with semi-structured questions, and ending with structured ones. This facilitated the building of background and rapport such that it become easier for participants to summarise what they felt to be significant in the interview session, and finally directed explicitly toward research questions. The nature of the interview questions may have been the most significant factor in obtaining the kind of relevant
data for this research. The interview questions were developed in alignment with research questions. Also, during the interviews, salient topics from questionnaire data were probed more deeply in individual interviews.

The interview data was highly valued as it allowed access to description of past events such as teacher preparation, and critical classroom experiences. In this way, it was possible to make inferences about the Integrated Science teacher knowledge from their verbal behaviour (Maxwell J. A., 2013). Some interviews were audio recorded whilst five interviewees refused to be audio recorded, in which case the researcher resorted to writing down notes for immediate transcription and translation into English before analysis. During the interview some of the IS teachers responded some questions in their indigenous language, Shona and sometimes code-switching with English language. All transcripts were translated into English language. The analysis of the transcripts focused on the identification of regularities or patterns in the reports made by participants, with the use of an apriori established system of categories. Analysis of the interview data generated findings of common themes and fundamental concepts that addressed the research questions. The interview ended with a thank you and goodbye.

### 3.6 Analytic Procedure

The process of analysis of quantitative and qualitative data is presented in this section. Analysis of the close-ended responses to the questionnaire was electronically done on IBM SPSS (Statistical Package for Social Science) version 24 software whereas the rest of analyses were carried out through MAXQDA Analytics Pro 12.
3.6.1 Quantitative data analysis

Descriptive statistics on IBM SPSS 24 was the basis of quantitative data analysis. Descriptive statistical analysis aimed at finding out the frequency and percentage of agreement and disagreement among the participants regarding the various issues raised in the questionnaire.

Quantitative evidence is presented first in the form of tables and graphs with percentages having certain opinions about teacher knowledge topics. One reason for using this format was to combine thematically-relevant issues together. Combining several items of the questionnaire helped in reduction of the number of topics to be dealt with. Another reason for the use of this format was to integrate quantitative and qualitative evidence together. The statistical information presented in the tables and was useful in informing the qualitative discussion. It helped in extending the argument by presenting the number and supplementing through discussing the nature of the issues addressed. This format also served to triangulate quantitative and qualitative evidence.

Quantitative analyses were applied to the Likert-scale data. The questionnaire responses data was broken into three independent subgroups of teachers. There were 60 Integrated Science teachers of which 20 were chemistry education specialists, 20 biology education specialists and another 20 were physics education specialists. The three groups were considered independent as the selection of the research participants for analysis in one group was not dependent upon the selection of the participants in the other groups (Tanner, 2012). The group parameters for the study were predetermined to be teachers who specialised in Chemistry education, Biology education, or Physics education. The data set of this research is not normally distributed.
because the Likert-scale scores collected are ordinal data, and ordinal data does not meet standards of normality (Tanner, 2012). The collected ordinal data in Section B of the questionnaire instrument was based on a ranked scale on which the research participants rated their thoughts and views of what constitutes Integrated Science teachers’ knowledge, the challenges they face in their practice and their levels of perceived preparedness for teaching Integrated Science. The ordinal data did not provide exact numerical scores related to proficiency in Integrated Science instruction for the participants. Because of these reasons, ordinal data cannot be normally distributed (Tanner, 2012).

The data set of section B of the questionnaire of this research met the parameters for nonparametric statistical analysis, which is what is used when the data is of ordinal scale and is not normally distributed. There were three independent groups predetermined by Science Education specialisation area with twenty research participants in each group. Therefore, the statistical test chosen to determine statistically significant differences between the responses of each group was the Kruskal-Wallis test (Tanner, 2012).

The Section B questionnaire data which was not positive on the Kruskal-Wallis test was presented via descriptive statistics (frequencies) for twelve questionnaire items. This was followed by the presentation of Kruskal-Wallis test results performed on the Likert-scaled items conducted using IBM SPSS Statistics 24. The independent variable, or categorical variable, was the qualification (subject specialisation) group to which the Integrated Science teacher belonged. The dependent variables were fifteen Likert-scale ordinal data statements. The analysis was based on the following hypotheses:
$H_0$: The three groups have the same distribution of scores.

$H_A$: At least two of the groups will contain a statistically significant difference in the distribution of scores.

The Kruskal-Wallis test on SPSS calculated the medians for the three subject specialisation qualification groups and then it calculated the statistical significance of the test results, which either affirmed or denied the null hypothesis. The information regarding the items which had statistically significant difference between groups was provided by the SPSS. Out of the fifteen Likert-scale statements on the questionnaire, one statement resulted in a statistically significant difference between groups as noted by the Kruskal-Wallis score, where $p < 0.05$. As the Kruskal-Wallis score does not indicate between which two groups the differences occur, a pairwise comparison post-hoc tests on this item with statistically significant differences was carried out to determine which two groups differed significantly in their responses.

The Kruskal-Wallis test provided information on whether or not the three groups being analysed had statistically-identical scores. If the Kruskal-Wallis score was not statistically significant, then all three groups were statistically identical, meaning they generally felt the same way about the Likert-scale statement. If the Kruskal-Wallis score did show statistical significance, then at least one of the three groups differed significantly from the others on its view of the Likert-scale statement (Tanner, 2012). The Kruskal-Wallis, however does not inform on which of the three groups differ from the other two, or if all the three groups are significantly different from each other. Therefore, some pairwise multiple comparisons among the groups should be performed to locate the source of significance (Liu & Chen, 2012). When the Kruskal-Wallis test
result is a statistically significant score on a specific Likert-scale statement, this means that there is a statistical difference in opinion with at least one of the three groups, and therefore a post-hoc test has to be performed. A post-hoc test is specifically used for such a situation, to determine which group among the three had a significant variation from the others. The Dunn’s (1964) procedure with a Bonferroni correction was chosen for post-hoc testing. Each possible pair of scores against the complete data set for that statement were assessed through the pairwise comparison. Through the pairwise comparison and significance levels adjustment with the Bonferroni correction, a group that was significantly different from the others in its responses to individual Likert-scale statements was determined. The significance levels were adjusted through the Bonferroni multiple comparisons which controls the family-wise significance level at 0.05 and therefore minimised the increased risk of error that naturally occurs when performing multiple comparisons (Norman & Streiner, 2008). This lowered the alpha levels significantly, eliminating all of the significant differences that had been found at the .05 alpha levels. It should be noted that a Bonferroni correction application however often result in an overcorrection (Norman & Streiner, 2008), which may result in false negatives or the masking of significant results.

3.6.2 Qualitative data analysis

The data from interviews and the responses to the open-ended section in the questionnaire were analysed qualitatively. This analysis was through MAXQDA Analytics Pro 12 and manual analysis. The inclusion of manual analysis had its merits in that while doing the transcripts, the researcher had familiarity with and had a feel for the data and what it involved. It helped in engaging well with the data giving an opportunity to write memos while transcribing the data (Gibbs, 2007). The analysis was
fine-tuned through repeated reading of the data transcripts and refinement of the analysis more than once basing on the feedback obtained from the participants, discussion with colleagues regarding the suitability of certain ideas under certain categories and feedback from supervisors about the quality of the analysis. The categories of Integrated science teacher knowledge emanated from this analysis.

The qualitative evidence analysis followed; organisation of the data, coding and, descriptive and explanatory accounts as the three main procedures. This approach is similar to Huberman & Miles (1994)’s ‘transcendental realism’ qualitative data analytic framework.

3.6.3 Organising the qualitative data

All the qualitative data from the free-response section of the questionnaire was transcribed and stored as a soft copy on MAXQDA Analytics Pro 12 software. The researcher read through the transcripts to get the general feeling and idea of the respondents. During data organisation, due to the voluminous, messy, unwieldy and discursive nature of qualitative data (Spencer, Ritchie & O’Connor, 2003), data reduction was initiated and continued throughout the analysis (Punch, 2009). Data reduction made large amount of data manageable. It entailed editing, segmenting and summarizing of the data. The researcher’s initial thoughts summaries and notes on data analysis were also added on the MAXQDA Analytics Pro 12 during data reduction. Of note was avoidance of stripping the data from its context and avoiding significant loss of information upon reducing the bulky data. For this reason, manually analysis was integrated as part of data analysis as well as noting on MAXQDA Analytics Pro 12.
The original research questions were revisited to find out how they were being answered followed by observation of the other ideas and themes that have arisen from the data (surprises). During data organisation a cursory look at the data coverage was made through familiarization with the data and identifying recurring broader topics under which the data was labelled, sorted and compared. This thematic framework went through a number of refinements after the first and subsequent applications. Some categories were collapsed while emerging ones are integrated.

### 3.6.4 Coding Strategy

Qualitative data transcripts were analysed sequentially. Initial codes were developed during open coding (Merriam, 2009) in MAXQDA Analytics Pro 12 software. Comments were implanted in the document (as memos) as each transcript was analysed, and these comments were the basis of preliminary codes. These preliminary codes represented an initial stage of data reduction, whereby noteworthy statements from the interviewees were refined down into specific categories. Some of the preliminary categories that were developed were: Teaching of Integrated Science is derived from, Preparedness to teach IS after graduating, Teacher education curriculum change, Changing IS curriculum, IS teaching support, Challenges encountered in teaching IS and Relevance of my area of specialisation in teaching IS.

As each interview was conducted, the researcher compared the preliminary codes that had been developed from the previous questionnaire’s open-ended section data to see if similarities would emerge.
The preliminary codes were then congregated and reorganized into themes during analytic coding (Merriam, 2009). For example, the initial codes of teacher education curriculum change and relevance of my area of specialisation in teaching IS were combined under the umbrella of “preparedness to teach IS,” which ultimately became the second emergent theme. The resultant main codes are displayed in Table 2. Each theme was broken into two clusters: types of knowledge and sources of knowledge.

<table>
<thead>
<tr>
<th></th>
<th>Main code categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Preparedness to teach IS</td>
</tr>
<tr>
<td>2</td>
<td>My IS teaching is derived from</td>
</tr>
<tr>
<td>3</td>
<td>Relevance of area of specialisation in the teaching of IS</td>
</tr>
<tr>
<td>4</td>
<td>Confidence in teaching IS</td>
</tr>
<tr>
<td>5</td>
<td>Challenges encountered in teaching IS</td>
</tr>
<tr>
<td>6</td>
<td>Most enjoyable when teaching IS</td>
</tr>
<tr>
<td>7</td>
<td>Instructional strategies used in teaching IS</td>
</tr>
<tr>
<td>8</td>
<td>Important scientific ideas which IS students should learn</td>
</tr>
<tr>
<td>9</td>
<td>Integrated Science Curriculum change</td>
</tr>
<tr>
<td>10</td>
<td>Reforming Teacher Education Curriculum change</td>
</tr>
</tbody>
</table>

Coding involved display of data through finding themes, clusters and patterns. The qualitative data was meaningful segmented into categories and sub-categories and synthesized based on meaningful segments.

The categories and sub-categories of the preliminary analyses were given codes. These codes were then used on the rest of the analysis. Emerging code during the process were incorporated as the analysis progressed. Irrelevant data was left out and hence reducing the data. Data reduction was automated in MAXQDA Analytics Pro 12 through selection of specific segments ‘quotes’ which aligned with specific codes and memos. Memos had as intention to capture the birth of ideas in the researcher’s mind. This reduced data became the basis of analysis.
Qualitative data sorting facilitated the relatively rapid retrieval and comparison of all the data marked with the same code despite the large volume of it (Gibbs, 2007). The data was coded through putting labels against pieces of the data. Labelling of data pieces attached meaning to them. The labels indexed the data, making it easy to store and retrieve. The initial labels gave room for advanced coding, which ended-up in the summarizing of data by pulling together themes, and by identifying patterns.

Two types of codes were used; low inference descriptive and higher inference/pattern (conceptual/analytic) codes (Huberman & Miles, 1994). Descriptive codes had as main intention to identify and label what is in the data whilst pattern codes interpreted and interconnected the identified and labelled data (Punch, 2009). Some codes were pre-specified (coding frameworks) whilst others emerged from the data. The questionnaire and the theoretical framework of the study guided the generation of pre-specified codes, whilst other categories emerged from the data. This kind of analysis followed a series of inductive and deductive steps in which case data driven hypothesis generation was followed by deductive hypothesis examination for verification purposes (Punch, 2009).

A thematic chart for each topic was created including all the coded segments from all the data sources organized under a system of sub-topics and categories. The aim of this analysis was to reflect the realities expressed by the data source instead of applying the conceptual framework to the data. Some of categories data were of course anticipated because the research revolved around the concept of teacher knowledge. However, this did not mean to conduct the analysis with the aim of looking for what is in the theoretical framework and excluding the agenda of the data from sources because it did not cohere with the theoretical framework of the research. If it were so, apart from being
unethical, the research would be ignoring the multiple realities of the phenomenon being investigated. This would have exposed the tension between the ontological assumptions of the researcher and the methodological practices followed. On the contrary, it was the crediting of these realities which led to the contribution of the findings to what is already there. Therefore, while presenting the findings, some categories were guided by the questionnaire responses, whilst others were constructed from emergent issues.

Data analysis was carried out both deductively and inductively. The research questions and the questionnaire items gave access to some of the topics and categories (codes) to start with. Other topics and categories (codes) were constructed during the analysis. After manual transcription, some topics and categories were derived from the notes. The organised data was then revisited case by case to apply the resulting topics and categories and to find new categories that emerged. The verbatim data of each source was divided into meaningful segments to synthesize the categories. Whenever none of the initial categories resulting from the data organisation stage could be applied to a data source segment, a new category was constructed. A list of all categories and subcategories, which resulted from the analysis of the data, was prepared at the end of the analysis of each data source. These resulting lists were used for combining similar categories. Thematic charts across all the data sources were then prepared. Each thematic chart represented a category or sub-category shared by all the data sources. Once all thematic charts were ready, the coded scripts were segmented and classified according to the thematic categories. Similar categories are grouped together into topics and sub-topics. Further refinement of the topics and categories took place during the analysis and after feedback from research advisors, colleagues and respondents. This
ensured that the ideas fit well under certain categories and topics and it validated the analysis.

3.6.5 Drawing and verifying conclusions

The aim for organising and coding qualitative data was to assist in drawing conclusions (Punch, 2009). While conclusions were being drawn following a rigorous logical organisation of data and coding that data, however, this in fact took place more or less concurrently with these procedures. So, the procedure of drawing conclusion was from the beginning, although at first it was ill-formed.

The three processes of detection, categorization and classification helped in generating descriptive accounts. Detection involved looking within a theme, across all participants in the study and noting the range of views and experiences which were labelled as part of that theme. The aim of detection ensured the relevance of each idea articulated by the participants within each theme which assisted in developing an outline of the supporting ideas to be included under it. Initially detected categories and/or themes were filtered and emergent refined categories data assigned through the categorisation process. This took place through the incorporation of feedback from the research advisors. Classification resulted in further refining of the categories and identification of fewer classes by which to sort, encapsulate and present the data.

Patterns and relationships in the data were identified in order to go beyond the descriptive data analysis (Gibbs, 2007). Identification of patterns and relationships was done through observing similarities and differences across different cases. Results of the questionnaire and interviews were compared (Creswell & Plano Clark, 2011). Such comparison was important as it occasional gave rise to the need for explaining the
occurrence of particular patterns and relationships. Explanatory accounts involved: detecting patterns of association or clustering, verifying associations and developing explanations (Gibbs, 2007). Pattern detecting involved finding linkages and associations in the data and was a product of analysis of both quantitative and qualitative data.

The level of linkages and associations spread across the data set was presented as a percentage or frequency. An interrogation of the patterns of association was made giving possible reasons of the occurrence of such pattern(s) and further interrogating any cases that did not fit into the observed patterns. Other empirical studies were also drawn upon to borrow concepts or explanations to examine how well they fit the observed patterns.

3.7 Limitations

During the course of the data collection and analysis a number of limiting factors emerged, which affected the study’s scope and design. Although the findings of this study provided a thorough description of the knowledge base of a sample of Secondary School teachers for teaching Integrated Science in Zimbabwe, the outlined limitations should be noted while interpreting the findings. A major limitation of this study was the lack of any studies done with this intention in the past.

3.7.1 Design Limitations

A mixed methods design consisting of two data collection phases was employed in this study of Integrated Science teachers who have specialised in Chemistry, Biology or Physics education. During the first phase, the questionnaire may have led to potential marginalisation
of certain types of knowledge; and for this reason, the open-ended questions were added to the questionnaire and the qualitative phase was designed to broaden the types of knowledge that could be uncovered in this study. Nine teachers were selected for a qualitative phase from a pool of sixty participants who had participated in the quantitative/survey phase of this research. As such, the interview responses of these participants may have been influenced by their participation in the survey phase.

3.7.2 Data Collection Limitations

The data collection procedures presented various limitations in this study. The study was limited to a relatively small sample in the quantitative data collection phase (n = 60), although the response rate was just over 92%. This sample size was low because the teachers teaching Integrated Science who have specialised in Chemistry, Biology or Physics are not evenly spaced and contemplating capturing all these teachers all over the country would not have been logistically feasible. Due to these challenges the study followed a snowball sampling technique. It was assumed that Integrated Science Teachers are affiliated through links that can be taken advantage of to trace other respondents based on the informants. As sample members were not selected from a sampling frame, the snowball sample was subject to numerous biases. It is possible and logical that respondents with many links were more likely to be recruited into the sample than those with less. There was the possibility that isolated IS teachers were most likely not included in the study. It is probable that there was some bias due to possibly poorly worded interview questions and likely reflexivity where the interviewee gave the researcher the response he wanted to hear (Yin, 2014).
3.7.3 Data Analysis Limitations

The Dunn’s procedure with a Bonferroni correction was chosen for post-hoc testing, to determine which cohort among the three (Biology, Chemistry and Physics education specialism) had a significant variation from the others. The application of a Bonferroni correction can often result in an overcorrection (Norman & Streiner, 2008), which may result in false negatives or the masking of significant results. Vasilopoulos, Morey, Dhatariy, & Rice, (2016) however, clarifies that a lack of statistical significance should not be considered necessarily as a lack of practical significance. Significance testing (the ability or power to reject the null) is dependent on sample size and does not give any indication of the relevance of a finding. During the qualitative phase of this research possible bias existed on the part of the researcher or response bias of the interviewee as the researcher possibly analysed the interview data through the biased lenses of his conjectures. On the same vain, the response bias of the interviewee could have possibly originated as the interviewee strived to answer within the mind frame of the interviewer.

3.8 Assumptions

Within the context of this study it is taken for granted that:

1. Teacher knowledge can be documented (Lee & Luft, 2008; Ogletree, 2007; Hagevik, et al., 2010).

2. The Integrated Science teachers who participated in this study made a conscious effort to answer questions, reflect, and make assessments as they expressed themselves through a variety of means.

3. Integrated Science Teachers are affiliated through links that can be taken advantage of to trace other respondents based on the informants.
4. The privacy and confidentiality of the study participants was seen by the participants to be protective enough such that honest responses were given by them, during the research.

5. Teacher Knowledge is contextual and can be qualified by experiences, stories, and examples of practising teachers and that this knowledge is developed and gained through their experience, service and reflection.

6. Secondary teacher education programs are not providing all of the science content knowledge teachers need to teach the Integrated Science subject effectively (Akerson, 2005; Ball D. L., 2000; Feiman-Nemser, 2001; Roehrig & Luft, 2004).

7. Significant teacher learning takes place as teachers teach in their own classrooms (Akerson, 2005; Roehrig & Kruse, 2005).

8.Finally, this research assumed that the IS teachers who participated had the adeptness to link their experiences and recollections to their present practices, as such, lived experiences are deemed significant enough to enlighten their practice.

3.9 Ethical considerations

The research was conducted taking into consideration a set of ethical issues which guided the research process. Wellington (2000; p. 3) exposes that “ethical concerns should be at the forefront of any research project and should continue through the write-up and dissemination stages”. The study was guided by the ethical principles outlined in the subsequent paragraph.

The need to protect the participants’ confidentiality and anonymity, and to give them the right to withdraw from the study at any stage was be borne in mind throughout the research process. Informed consent was sought from the participants prior to the administration of the research tools. All the participants were made aware of the aims
of the research and its procedures. Participants who felt not at easy in being part of the research were not be selected. Actual names of research participants were not used as the results of the study were being reported.

3.10 Summary of the Chapter

This chapter described the guiding research methodology for IS teacher knowledge research used in the present study. The role of the researcher in this study was described. The study identified the sample of IS teachers who participated in the study and how they were selected through the use of criterion and snowball sampling. The data collection and analytic tools which addressed the research questions of the study were identified and described. Ethical considerations were presented to assure the right of participants to privacy. The next chapter presents the research results.
Chapter Four
Results

4.0 Introduction

The research findings in this chapter are presented and analysed through two major sections: the first section analyses the questionnaire responses which is then followed by analysis of the interview responses. The analysis of the questionnaire responses section is partitioned into the subheadings: Results from Section A of the questionnaire, Results from Section B of the questionnaire and Results from Section C of the questionnaire. The research findings from Section A of the questionnaire are further analysed through gender, age range and teaching experience categories. The semi-structured interviews responses are analysed through a framework of five emerging knowledge themes, which are: “About education background of the respondent”, “About teaching background”, “About learning”, “About IS teaching in general”, and “About school factors”. The chapter is then rounded up through a summary.

4.1 Analysis of the questionnaire responses

Likert-scale data of the questionnaire is analysed through descriptive statistics. Analysis of data from Section C of the questionnaire followed transcendental realism qualitative data analytic framework whereby data was organised, coded, described and explained (Huberman & Miles, 1994).

4.1.1 Results from section A of the questionnaire

**Gender:** All respondents chose to report on their gender (female or male), and the results are detailed in Table 3. Twenty five percent of respondents reported as female, and seventy five percent reported as male.
Table 3

<table>
<thead>
<tr>
<th>Gender of respondents</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>45</td>
<td>75.0</td>
</tr>
<tr>
<td>Female</td>
<td>15</td>
<td>25.0</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The gender representation of the respondents is a general reflection of the state of affairs in Zimbabwe whereby the majority of science teachers are males whilst females are found being the majority in subjects such as languages.

**Age ranges.** Fifty four of the sixty respondents chose to disclose their age range, selecting from the following categories: 20-24 years; 25-29 years; 30-34; 35-39; 40-44 and 45 or older years. The results are detailed in Table 4. 57.4% of respondents reported being 39 or younger, and 42.6% of the respondents were over 40.

Table 4

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-24</td>
<td>1</td>
<td>1.7</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>25-29</td>
<td>3</td>
<td>5.0</td>
<td>5.6</td>
<td>7.4</td>
</tr>
<tr>
<td>30-34</td>
<td>12</td>
<td>20.0</td>
<td>22.2</td>
<td>29.6</td>
</tr>
<tr>
<td>35-39</td>
<td>15</td>
<td>25.0</td>
<td>27.8</td>
<td>57.4</td>
</tr>
<tr>
<td>40-44</td>
<td>13</td>
<td>21.7</td>
<td>24.1</td>
<td>81.5</td>
</tr>
<tr>
<td>45+</td>
<td>10</td>
<td>16.7</td>
<td>18.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
<td>90.0</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>6</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td>60</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The 35 to 39 years of age range had the highest number of participating IS teachers, whilst the least number of participants were in the 20 to 24 years age range. The presentation of the data on age and gender whilst studying Teacher Knowledge aid in understanding the context and focus of the participants’ life history (Seidman, 2013).
**Teaching Experience.** All respondents but two reported the years of secondary school teaching experience, and the results are displayed in Table 5 below. The experience varied from two years to above ten years. 67.2% of the respondents had over ten years of teaching experience whilst 15.5% had below four years of teaching experience.

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Biology Education</th>
<th>Chemistry Education</th>
<th>Physics Education</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teaching Experience</strong></td>
<td>Two to Four Years</td>
<td>Five to Nine Years</td>
<td>Ten+ Years</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>10</td>
<td>39</td>
<td>58</td>
</tr>
</tbody>
</table>

The majority of the participating IS teachers were highly experienced with over ten years of teaching experience whilst the least experienced teachers were in the teaching experience range of two to four years. These highly experienced and mature teachers were deemed the most suitable participants expected to respond to research items basing on reflection.

### 4.1.1 Results from section B of the questionnaire

This section details the results of the quantitative phase of the study. Table 6 indicate the response frequency to the fifteen questionnaire items.
## Table 6

Summary of the questionnaire items frequency

<table>
<thead>
<tr>
<th>Code</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Valid N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
<td>Frequency</td>
<td>Percent</td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>1.</td>
<td>15</td>
<td>25.0</td>
<td>29</td>
<td>48.3</td>
<td>8</td>
<td>13.3</td>
</tr>
<tr>
<td>2.</td>
<td>29</td>
<td>48.3</td>
<td>23</td>
<td>38.3</td>
<td>2</td>
<td>3.3</td>
</tr>
<tr>
<td>3.</td>
<td>32</td>
<td>53.3</td>
<td>19</td>
<td>31.7</td>
<td>6</td>
<td>10.0</td>
</tr>
<tr>
<td>4.</td>
<td>22</td>
<td>36.7</td>
<td>28</td>
<td>46.7</td>
<td>5</td>
<td>8.3</td>
</tr>
<tr>
<td>5.</td>
<td>13</td>
<td>21.7</td>
<td>16</td>
<td>26.7</td>
<td>6</td>
<td>10.0</td>
</tr>
<tr>
<td>6.</td>
<td>17</td>
<td>28.3</td>
<td>16</td>
<td>26.7</td>
<td>3</td>
<td>5.0</td>
</tr>
<tr>
<td>7.</td>
<td>8</td>
<td>13.3</td>
<td>23</td>
<td>38.3</td>
<td>7</td>
<td>11.7</td>
</tr>
<tr>
<td>8.</td>
<td>8</td>
<td>13.3</td>
<td>15</td>
<td>25.0</td>
<td>6</td>
<td>10.0</td>
</tr>
<tr>
<td>9.</td>
<td>6</td>
<td>10.0</td>
<td>9</td>
<td>15.0</td>
<td>7</td>
<td>11.7</td>
</tr>
<tr>
<td>10.</td>
<td>42</td>
<td>70.0</td>
<td>14</td>
<td>23.3</td>
<td>2</td>
<td>3.3</td>
</tr>
<tr>
<td>11.</td>
<td>4</td>
<td>6.7</td>
<td>9</td>
<td>15.0</td>
<td>18</td>
<td>30.0</td>
</tr>
<tr>
<td>12.</td>
<td>3</td>
<td>5.0</td>
<td>3</td>
<td>5.0</td>
<td>6</td>
<td>10.0</td>
</tr>
<tr>
<td>13.</td>
<td>17</td>
<td>28.3</td>
<td>22</td>
<td>36.7</td>
<td>5</td>
<td>8.3</td>
</tr>
<tr>
<td>14.</td>
<td>4</td>
<td>6.7</td>
<td>24</td>
<td>40.0</td>
<td>10</td>
<td>16.7</td>
</tr>
<tr>
<td>15.</td>
<td>7</td>
<td>11.7</td>
<td>21</td>
<td>35.0</td>
<td>9</td>
<td>15.0</td>
</tr>
</tbody>
</table>

**Code**

1. Need of student culture knowledge
2. Importance of Knowledge of History of Science in teaching
3. Teaching Practicals as important as teaching Theory
4. Practical Work enhance student learning
5. Teaching Integrated Science is different from teaching other science subjects
6. Specialising in a science discipline is important in teaching IS
7. I could be a better teacher if I had not specialised in one science discipline
8. When teaching a particular section of IS, I divert and teach another aspect of IS if that aspect captures student interest at that time
9. The rate of student learning does not impact my teaching of IS
10. Audio and visual aids are important in facilitating student learning of IS
11. IS teaching should mostly be done outdoors
12. I have not been trained in the use of IT as a science teaching aid
13. The subject matter/content taught at college is enough for one to teach IS
14. Upon being employed, I had to start reading hard in order to be able to teach those topics in IS divorced from my area of specialisation
15. IS teaching should mostly be conducted in-doors i.e. in laboratories or classrooms
As indicated on Table 6 the response rate to the Likert scale items was high. However, three respondents each, making up 5% per questionnaire item 5 and 15 did not attempt to respond to these. These high response rate might be pointing to the high drive of the participants to partake in this research and as well the issues being interrogated by this research resonated with the concerns that the IS teachers have as they practice their profession. The following sections present and explicate the crosstabulation each of the questionnaire items against the respondents’ specialisation.

On being asked to indicate the degree of agreement to questionnaire item statement 2 saying, “It is important for IS teachers to know the history of science”, the IS teachers’ response is presented on Figure 5 cross tabulated with their area of teaching specialisation.

![Figure 5](image)

*Crosstabulation of Qualification and Importance of Knowledge of History of Science in teaching*

The IS teachers who specialised in Biology and Physics were in agreement to this statement matching at eighteen participants per cohort. Although sixteen participants
from the Chemistry cohort were in agreement to the statement, four participants from this cohort were in disagreement to the said statement as compared to one participant apiece for the Physics and Biology cohort. By and large about 87% of the participating IS teachers were in agreement with the importance of history of science in student learning. Literature has it that the history of science proffers vivid, concrete case studies that demonstrates the nature of scientific reasoning (Matthew, 1994; Pitt, 1990) and hence maybe that is the reason why the majority of IS teachers recognise its importance. The history of science provides an example of Pedagogical content knowledge which the IS teachers hold in the form of syntactic knowledge which are the agreements, norms, paradigms, and ways of establishing new knowledge that scientists in areas of science hold as currently acceptable (Gess-Newsome, 1999). Many science educators treasure the history of science as it uncovers the scientific process, instead of focusing solely on final products and possesses a great potential for a multifaceted improvement of the learning process and its results (Galili & Hazan, 2002)

84.4% of IS teachers agree to strongly agree on the importance of practical work in enhancing student learning (Figure 6) as compared to 8.3% who disagreed. From the results of the survey it emerged that teachers recognise the importance of practical work in Integrated Science. There is no remarkable divergence about the importance of practical work in school science (Kapenda, Kandjeo-Marenga, Kasandra, & Lubben, 2002) the main issues raised are on whether any such practical work endeavour genuinely supports learning and teaching.
About 48% of the research participants indicated that teaching IS is different from teaching other subjects whilst 36.7% viewed the teaching of IS as being similar to teaching any other science subject (Figure 7). The 36.7% IS teachers are missing the point on what constitute IS which according to Harrel (2010) is an approach to learning and teaching from an assortment of world-views, strategies, and resources; and the taking advantage of real-life situations for problem solving and critical thinking in the classroom. It therefore should be taught in a different way as compared to other science subjects.
Figure 8 shows the crosstabulation of IS teacher qualification against their views on the need for specialising in a particular science discipline in order to teach IS. 55% of the research participants were in agreement to strongly agreeing that specialising during preservice teacher education was important as a preparation for teaching IS, 38.4% were in disagreement whilst the rest were undecided. It can be observed from Figure 9 that the count of IS teachers who agreed were higher for the Biology cohort as compared to the other cohorts. This questionnaire item did not however interrogate if the IS teachers thought whether their subject area specialisation was the one which was need or not for IS teaching. The questionnaire item 7 interrogated this.
Crosstabulation of IS teacher qualification against the need for specialising in a particular science discipline in order to teach IS

Researches on teaching science topics within and outside areas of specialism reveal important differences in the quality of preparation and delivery of science lessons (Harrell, 2010; du Plessis, 2017; Nixon & Luft, 2015). IS teachers might find themselves feel out-of-field when found teaching those concepts which they are not specialised in, however, because of the nature of IS in Zimbabwe which has about 75% Biology content (ZIMSEC, 2010) the IS teachers might feel that those who specialise in Biological discipline are better-off.

On being asked on whether they concurred with that they would divert and teach another aspect of IS if that aspect captures student interest at that time when teaching a
particular section of IS, 38.3% of the research participants agreed 50% disagreed whilst 10% neither agreed nor disagreed and IS teacher did not respond to the item (Figure 9). The reason why 50% of the IS teacher participants are in disagreement with the statement item might be that these teachers remember instances of their teaching outside subject specialism in which situation according to Mizzi (2013) there is a tendency to be rigid, less confident in their teaching, following a textbook structure quite closely and tending to ask recall questions.

![Figure 9](image)

*Teaching that captures student interest*
The majority of the IS teachers were in disagreement to the questionnaire item statement which stated that the rate of student learning did not impact their teaching of IS.

61.7% of the participating IS teachers disagreed to strongly disagree, 25% agreed to strongly agreed, 11.7 % neither agreed nor disagreed and one teacher did not respond to the question. Across the 3 cohorts the IS teachers recognised the need to pace teaching with rate of student learning and in so doing the teachers acknowledge the ‘knowledge of students’ and ‘learner characteristics’ as propounded by Shulman (1987).
93.3% of the research participants were in agreement to strongly disagreeing that audio and visual aids facilitated student learning of IS whilst 3.3% neither disagreed nor agreed, two participants did not however respond to the questionnaire item (Figure 11). The level of concurrence to the importance of audio-visual aids in facilitating learning cut across all the three cohorts. The audio and visual aids have been identified by Grossman (1990) as the 3rd PCK knowledge of which teachers are expected to know the curricular materials available to enact the curriculum.

**Figure 11**

Audio and visual aids are important in facilitating student learning of IS

Audio and visual aids are important in facilitating student learning of IS

Item 11 of Section B the questionnaire asked on whether IS teachers agreed or not with the statement, ‘Integrated Science teaching should mostly be done outdoors’. 21.7%
were in agreement, 30% neither disagreed nor agreed whilst a substantial number of 48.3 disagreed to strongly disagree across the three cohorts (Figure 12).

**Figure 12**

Teaching of IS through outdoors activities

78.3% of the research participants indicated that they were well trained in the use of IT to aid IS teaching whilst 10% said the contrary and another 10% neither agreed nor disagreed. One teacher however did not respond to the questionnaire item. The response to this item is consistent to the response given to questionnaire item 10 where about 93% of the respondents indicated that audio and visual aids facilitate the learning of IS. Nyikahadzoyi (2013, p. 5) also acknowledged the need for teachers be holders of IT knowledge which he referred to as technological knowledge for the purpose of teaching when he referred to this knowledge as the knowledge of “Advanced digital technologies
knowledge of operating systems, computer hardware, ability to use standard sets of software tools such as word processors, spread sheets, browsers, and e-mail”.

75% of the IS teacher participants felt that the subject matter they were taught at college was adequate for enabling them to teach IS. 8.3% of the teachers were not sure whilst 26.7% felt that the content knowledge which they were taught was not adequate for IS teaching (Figure 14).
Adequacy of subject matter/content taught at college for the purpose of teaching IS

Whilst the majority of the research participants viewed subject matter they were taught at college as adequate for IS teaching albeit IS being multidisciplinary and them specialising in one science discipline, Shulman (1986) and Spear-Swerling & Cheesman (2012, p. 1692) warns that inadequate content knowledge by the teacher leads to constricted and regressionist pedagogies as teachers resort to replicating own past experiences which may result in teachers providing “inadvertently confusing instruction” to students especial in those concepts where they experience out-of-field phenomenon (Nixon & Luft, 2015).
31.7% of the respondents across the cohorts indicated that they were ill-prepared content-wise to teach IS when they joined the teaching profession from college whilst 56.7% said that they were well prepared to teach IS upon assumption of teaching duty from college, however, 8.3% of the research participants were neither in agreement nor disagreement that upon being employed they had to start reading hard in order to be able to teach those topics in IS divorced from their area of specialisation (Figure 15). Although the IS teachers acknowledge that there are some content topics in IS which lie outside their area of specialisation more than half of the participants still felt that they were adequately prepared to teach IS upon graduation. This might be due to the fact that most of these participants had learnt IS as a subject at secondary school level and hence the content was not actual new to them but might still however be lacking PCK (Shulman, 1987).

**Figure 2**

![Bar Chart](chart.png)

*Content knowledge taught at college versus actual teaching situation*
Item 15 of the questionnaire asked the research participants if they agreed or not on whether IS teaching should mostly be conducted in-doors i.e. in laboratories or classrooms. 36.7% of the participating IS teachers agreed to the teaching of IS indoors whilst 15% could neither agreed nor disagreed and 33.4% were in disagreement. Three research participants chose not to respond to the questionnaire item.

**Figure 16**

![Bar chart showing teaching preference]

**Teaching of IS in-doors**

On comparing the teachers’ responses of questionnaire items 11 and 15 it appears as if more of the research participants teachers preferred teaching IS indoors (36.7%) than outdoors (21.7) despite the fact that the teachers should take advantage of out-doors to facilitate learning through for example field observations (ZIMSEC, 2010).
Kruskal-Wallis test results

This section has tables representing the Kruskal-Wallis test data. For each questionnaire item, a chi-square score ($\chi^2$), and a Kruskal-Wallis p-value are displayed. The questionnaire item with a statistically significant p-value, where $p < 0.05$, is highlighted in yellow, as well, the just conditions highlighted in grey. A post-hoc test on the questionnaire item with a statistically significant p-value is also tabulated. The last column of the post-hoc test table displays the results of the Bonferroni correction, which determined if the difference between two groups of teachers was still statistically significant following an adjustment for multiple comparisons.

Only one questionnaire item in Section B is deemed significant (Table 7) and had statistically significant differences between groups of Integrated Science teachers, whilst two questionnaire items were deemed to be narrowly missing the limit of significance (Table 7). The Likert-scale statement for these are written and described below. Table 7 indicate that the responses to 14 questionnaire items showed no significant differences between the respondents’ scores on section B, at .05 alpha level. Items 1, 2 and 4–15 were not statistically significant. However, items 1 and 7 did show marginal significance at $p = 0.051$ and 0.084, respectively and hence considered as just conditions.
### Table 7
**Test Statistics a, b**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>5.850</td>
<td>2.885</td>
<td>6.792</td>
<td>.751</td>
<td>.917</td>
<td>4.406</td>
<td>4.917</td>
<td>1.517</td>
<td>1.522</td>
<td>1.087</td>
<td>.677</td>
<td>.703</td>
<td>.166</td>
<td>.923</td>
<td>3.643</td>
</tr>
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<td>df</td>
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<td>2</td>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>.054</td>
<td>.236</td>
<td>.034</td>
<td>.687</td>
<td>.632</td>
<td>.110</td>
<td>.086</td>
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<td>.581</td>
<td>.713</td>
<td>.704</td>
<td>.920</td>
<td>.630</td>
<td>.162</td>
</tr>
<tr>
<td>Exact Sig.</td>
<td>.051</td>
<td>.241</td>
<td><strong>.032</strong></td>
<td>.688</td>
<td>.637</td>
<td>.110</td>
<td><strong>.084</strong></td>
<td>.474</td>
<td>.474</td>
<td>.568</td>
<td>.719</td>
<td>.706</td>
<td>.921</td>
<td>.635</td>
<td>.163</td>
</tr>
<tr>
<td>Point Probability</td>
<td>.000</td>
<td>.002</td>
<td>.000</td>
<td>.001</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.007</td>
<td>.001</td>
<td>.001</td>
</tr>
</tbody>
</table>
Item 3 stated, “Teaching through practical work is as important as teaching theory in IS”. This item showed a significant difference in views regarding the statement between teachers who have specialised in chemistry education and those who have specialised in physics education during their teacher education programmes. The difference maintained statistical significance following the Bonferroni correction, where \( \text{adj. } p = 0.033 \). Integrated Science teachers who specialised in Chemistry education were much more likely to accept as true that teaching through practical work is as important as teaching theory in Integrated Science than those who specialised in Physics Education.

<table>
<thead>
<tr>
<th>Sample1-Sample2</th>
<th>Test Statistic</th>
<th>Std. Error</th>
<th>Std. Test Statistic</th>
<th>Sig.</th>
<th>Adj.Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry Education-Physics Education</td>
<td>-12.279</td>
<td>4.827</td>
<td>-2.544</td>
<td>.011</td>
<td>.033</td>
</tr>
<tr>
<td>Biology Education-Physics Education</td>
<td>-8.684</td>
<td>4.888</td>
<td>-1.777</td>
<td>.076</td>
<td>.227</td>
</tr>
<tr>
<td>Chemistry Education-Biology Education</td>
<td>3.595</td>
<td>4.827</td>
<td>.745</td>
<td>.456</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Table 8

*Questionnaire item 3's Pairwise comparison of teachers' qualification*

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is .05. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Of the questionnaire population of 58 Integrated Science teachers who responded to Item 3, 55.2% strongly agreed that teaching through practical work was as important as teaching theory, 32.8% agreed whilst 10.3% disagreed and 1.7% strongly disagreed.
Fig. 17 shows the cross tabulation of the results of the IS teachers’ responses to the questionnaire item number 3. Although the IS teachers generally strongly agreed with the statement that: “Teaching through practical work is as important as teaching theory in IS”; the level of strongly agreeing was more from the Chemistry education specialisation cohort than the other two cohorts. On the other hand, the Physics education specialisation cohort had more teachers disagreeing to the questionnaire statement item number three as compared to the other two cohorts.

Fig. 17 shows that fifty-Two Integrated Science teachers which is about ninety percent of the respondents, agreed to strongly agreed that teaching IS through practical work is as important as teaching it theoretical, whilst six (10%) disagreed to strongly disagreed to this.
The questionnaire item number 1 stated, “Teaching Integrated Science (IS) requires knowledge of students’ culture.” Of the IS teachers who specialised in Biology Education 85% indicated that teaching IS require as a prerequisite some knowledge of students’ culture. This was at par at 85% with IS teachers who specialised in Chemistry education at college whilst only 50% of IS teachers who specialised in Physics Education were in agreement that teaching IS requires knowledge of students’ culture. Fig. 18 shows the crosstabulation of the aggregate responses of the three cohorts to questionnaire item number one.

**Figure 18**

Teaching IS requires knowledge of students’ culture
70% of IS teachers who specialised in Chemistry Education viewed the importance of not specialising in a single science discipline as they agreed to questionnaire item number 7. Questionnaire item number 7 stated, “I could be a better teacher of IS if I had not specialised in one science discipline at college,” and 60% of IS teachers who specialised in Biology Education were in agreement with Item 7. For those who specialised in Physics education only 25% of IS teachers reported as agreeing to being a better teacher if they had not specialised in only Physics Education.

**Figure 19**

As is shown on Fig. 19 those teachers who specialised in Physics education at college are more inclined to the view that being specialised in physics education is enough for one to be a better IS teacher.
The questionnaire items 3, 1 and 7 were more pronounced in the development of the interview guide. These questionnaire items interrogated issues around practical work, student culture and teachers’ areas of specialisation.

4.2 Results from Section C of the questionnaire

The open-ended survey responses are reported through the ten emerging themes. The identity of the respondent in the vignettes is codified as T#B, T#C or T#P indicative of teacher who specialised in Biology education, Chemistry education or Physics education.

4.2.1 Theme 1: Preparedness to teach IS

Eighteen teachers who specialised in Biology education (TB) (90% of TB), fourteen teachers who specialised in Chemistry education (TC) (70% of TC) and eight of teachers who specialised in Physics education (TP) (40 % TP) indicated that their area of specialisation was a relevant preparation to teach IS. Table 8 present this data.

<table>
<thead>
<tr>
<th>Relevance of area of specialisation in the teaching of IS</th>
<th>Document group &gt; Biology</th>
<th>Document group &lt; Chemistry</th>
<th>Document group &lt;&gt; Physics</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18</td>
<td>14</td>
<td>8</td>
<td>40</td>
</tr>
</tbody>
</table>

T08B articulated this as, “My college preparation was quite relevant”, whilst T39C said, “Specialising in chemistry is largely relevant”, and T54P emphasized that, “University/college preparation provided a firm base to the knowledge required in the
teaching of IS”. It should be noted that only 40%, less than half of the teachers from the Physics education specialism felt that their area of specialisation was relevant.

Overall, sixty-seven percent (67%) of the participants view their college preparation as relevant enough preparation for IS teaching and a sizeable thirty-three percent (33%) thinks otherwise. T24B expresses a “knowledge gap” which he experienced during his first year of teaching as he grappled with the realities of the profession. T56P buttresses this position by indicating that specialising in physics provides little assistance to enable one to teach IS, “except in the teaching of mechanical structures and science in Industry”, in concurrence T66P, T55P, T67P, T68P indicated that they encountered problems after graduation upon assuming the Integrated Science teaching position, whilst T49C bluntly points that her “area of specialisation does not real aid” in the teaching of Integrated Science.

Figure 20

Challenges encountered upon being engaged to teach IS

Whilst 37% of teachers indicated that they did not encounter any problems upon graduation, a sizeable number, 25% of IS teachers indicated that they struggled in teaching IS in their first year of engagement as IS teachers (Figure 12). Shulman (1986; 1987) emphasised the normatively/prescriptive oriented structural analysis of Teacher Knowledge which is hinged on what Teacher Knowledge should be, i.e., the espoused
knowledge. Viewing Teacher Knowledge within the framing of prescriptive orientation means that what teachers bring to the classroom from the colleges in terms of knowledge is of utmost importance as it has a direct bearing on their classroom performance. One would hope that college preparation should be enough initiation for teaching but in the case of this study 37% of the participants felt that they were not adequately prepared to teach IS. IS is the science subject taken by most students in Zimbabwe.

4.2.2 Theme 2: My IS teaching is derived from

Integrated science teachers identified various sources from which they derived their teaching of IS. These sources are sub-coded into: educational background of the IS teacher, teacher’s learning through practice (experiential learning) and inquiries conducted in preparation for teaching IS.

Educational background of the IS teacher

The teachers who specialised in Biology education indicated a number of courses which they took at college which aid them in the teaching of IS. Most of these courses as indicated by T24B, however, “mainly helps in the teaching of Science in Agriculture section and there is need to learn other sections on the go”. The courses identified by T#B teachers are tabulated on Table 10.
Table 8
Courses identified by T#B as essential in IS teaching

<table>
<thead>
<tr>
<th>Courses</th>
<th>Identifying teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological sciences laboratory techniques</td>
<td>T08B, T09B</td>
</tr>
<tr>
<td>Microbiology</td>
<td>T08B, T06B</td>
</tr>
<tr>
<td>Professional studies</td>
<td>T04B</td>
</tr>
<tr>
<td>Advanced Level Biology, Physics and Chemistry</td>
<td>T02B, T17B, T18B, T23B</td>
</tr>
<tr>
<td>History of Science Education</td>
<td>T13B</td>
</tr>
<tr>
<td>Philosophy</td>
<td>T08B, T06B</td>
</tr>
<tr>
<td>Psychology of education</td>
<td>T07B, T25B</td>
</tr>
<tr>
<td>Sociology</td>
<td>T08B, T06B</td>
</tr>
<tr>
<td>Pedagogics</td>
<td>T08B, T06B</td>
</tr>
<tr>
<td>Curriculum studies</td>
<td>T08B, T06B</td>
</tr>
<tr>
<td>Genetics</td>
<td>T08B, T06B</td>
</tr>
<tr>
<td>Educational technology</td>
<td>T09B, T21B</td>
</tr>
<tr>
<td>Plant physiology</td>
<td>T23B</td>
</tr>
<tr>
<td>Biology</td>
<td>T05B, T17B, T07B, T08</td>
</tr>
<tr>
<td>Theory of education</td>
<td>T13B, T04B</td>
</tr>
</tbody>
</table>

Biology and High School Advanced Level courses are indicated by four teachers (20%) as essential background which enable them to better teach IS. This seems to be in concurrence with Grossman (1990), who says that teachers’ experience as High school students help them in developing PCK through ‘apprenticeship of observation’. Two teachers associate better preparation for teaching IS with learning Philosophy, Psychology, Sociology, Pedagogics, Curriculum Studies, Educational technology, Microbiology, Biological techniques or Theory of education in general. Plant physiology, History of Science and Professional Studies courses are identified by only a single teacher each.

The courses identified by IS teachers who had specialised in chemistry education (T#C) as essential for teaching of IS are tabulated in Table 11.
Subjects taken at secondary school level are identified by T#C teachers as most essential as preparation for teaching Integrated Science. Three T#C teachers said that secondary school science subjects were essential in enabling them to better deliver IS lessons. They alleged that these subjects formed the bedrock of IS teaching. High school/Advanced Level sciences, Chemistry area of specialisation and Practice teaching were identified by two teachers each whilst only a single T#C teacher identifies with; Micro techniques, Mathematics, Media technology, Philosophy, Curriculum studies, Psychology or First year courses.

Teachers who specialised in Physics education (T#P) felt that the courses tabulated in Table 12 were essential for effective preparation to teach Integrated Science.
### Table 12

**Courses identified by T#P as essential in IS teaching**

<table>
<thead>
<tr>
<th>Courses</th>
<th>Identifying teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science courses taught at college</td>
<td>T63P, T67P</td>
</tr>
<tr>
<td>High School Sciences</td>
<td>T63P</td>
</tr>
<tr>
<td>Electricity and magnetism</td>
<td>T71P</td>
</tr>
<tr>
<td>Applied Mechanics</td>
<td>T58P</td>
</tr>
<tr>
<td>Applied Heat and Management</td>
<td>T58P</td>
</tr>
<tr>
<td>Mathematics</td>
<td>T60P, T74P</td>
</tr>
<tr>
<td>Sociology and philosophy of education</td>
<td>T56P, T75P, T57P, T72P</td>
</tr>
<tr>
<td>Psychology of education</td>
<td>T57P, T75P, T59P, T72P</td>
</tr>
<tr>
<td>Curriculum design &amp; Implementation</td>
<td>T59P, T54P</td>
</tr>
<tr>
<td>Family, Health and Life studies</td>
<td>T72P</td>
</tr>
<tr>
<td>AVA (Audio Visual Aids)</td>
<td>T73P</td>
</tr>
<tr>
<td>Physics</td>
<td>T74P</td>
</tr>
</tbody>
</table>

The majority of the teachers who specialised in physics identified professional courses as essential for preparing to teach Integrated Science. Physics, AVA (Audio Visual Aids), Family, Health and Life studies, Applied Heat and Management, Applied Mechanics, Electricity and magnetism were listed by a teacher each. Of note is the identification of secondary and high school science subjects by three teachers as being an essential preparation for teaching IS.

All three cohorts of teachers identified secondary school science and professional courses as being essential foundation for teaching Integrated Science. It is interesting to note that despite these teachers having been taught a substantial amount of content courses in their area of specialisation they do not perceive these as essential for the teaching of IS serve for those who specialised in Biology who indicated five courses from their area of specialisation.
Overall, professional studies courses were cited by IS teachers as impacting positively in their teaching of IS.

**Inquiries conducted in preparation for teaching IS**

A number of teachers indicated that they had to carry out different forms of research for them to prepare for IS teaching. These different forms of inquiries are tabulated in Table 13.

**Table 13**

<table>
<thead>
<tr>
<th>Inquiry conducted in preparation for teaching</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journals</td>
<td>T06B</td>
</tr>
<tr>
<td>Past Examination papers and reports</td>
<td>T09B, T19B, T05B</td>
</tr>
<tr>
<td>Consulting subject specialist</td>
<td>T05B, T07B, T62P</td>
</tr>
</tbody>
</table>

When preparing to teach IS a substantial number of IS teachers (17) said that they consulted textbooks. 14 IS teachers said that they relied on the internet as a source when preparing to teach IS. It is worth noting that not even a single teacher who specialised in Chemistry save for T52C indicated any form of research as they prepare to teach IS.
Integrated Science teachers’ top sources for teaching were identified as textbooks, internet searches, college preparation and life experiences.

**Experiential learning**
Some IS teachers alluded to the fact that they learnt to teach through various forms of exposure as tabulated in Table 14.

**Table 14**

<table>
<thead>
<tr>
<th>Experience</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Club membership e.g. Environment 2000</td>
<td>T08B</td>
</tr>
<tr>
<td>Peer teaching &amp; Interactions with other teachers</td>
<td>T07B, T70P</td>
</tr>
<tr>
<td>In-house trainings</td>
<td>T13B</td>
</tr>
<tr>
<td>Teaching experience</td>
<td>T51C, T48C, T57P, T70P, T73P</td>
</tr>
<tr>
<td>Examination marking (Centralised marking)</td>
<td>T48C, T57P</td>
</tr>
<tr>
<td>Conference, Seminars and workshop attendance</td>
<td>T48C, T29C, T58P, T61P</td>
</tr>
<tr>
<td>Indigenous Knowledge</td>
<td>T61P, T59P,</td>
</tr>
<tr>
<td>Television programs</td>
<td>T61P</td>
</tr>
</tbody>
</table>
The number of years one spends as an IS teacher is identified by five teachers as having a significant contribution to being a better teacher. Four teachers also noted that Conference, Seminars and Workshop attendance have contributed immensely to their preparation to teach IS. Other experiences noted as being important to being a better IS teacher are Club membership, Peer teaching and interactions with other teachers, exposure to science television programs, indigenous knowledge, in-house training and examination marking. Of the IS teachers who indicated experience as essential for preparation to be a better IS teacher 56% were those who had specialised in Physics, 28% being those who had specialised in chemistry whilst only 17% were those who had specialised in Biology education. These figures might be pointing to the fact that maybe those who specialised in Biology feel better equipped for teaching IS upon graduation whilst at the far end those who specialised in Physics need some more years of experience, learning in the field to be better teachers of IS.

4.2.3  Theme 3: Confidence in teaching IS

Teachers expressed various levels of confidence in teaching IS ranging from confident to very much confident. These articulations of confidence levels appear in Table 16.

<table>
<thead>
<tr>
<th>Confidence Level</th>
<th>TB teachers</th>
<th>TC teachers</th>
<th>TP teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somewhat confident</td>
<td>T21B, T08B, T19B, T22B</td>
<td>T40C, T31C, T34C, T49C</td>
<td>T55P</td>
</tr>
<tr>
<td>Less confident</td>
<td>T23B</td>
<td></td>
<td>T58P, T54P</td>
</tr>
</tbody>
</table>
17 IS teachers from the Biology specialism cohort indicated that they were confident in teaching IS, of these teachers 3 were very much confident. One IS teacher from the Biology specialism cohort indicated that he was less confident in delivering IS lessons.

17 IS teachers from the Physics specialism cohort also revealed that they were confident when teaching IS and of these 2 were very much confident whilst on the other hand 2 IS teacher from this cohort proffered that they were less confident when teaching IS.

19 IS teachers from the Chemistry specialism cohort indicated that they were confident of which 2 from this group revealed that they were very much confident, whilst on the other hand no IS teachers from this cohort proffered that they were less confident when teaching IS.

Of the fifty-six IS teachers who responded to the question 79% expressed that they are were confident to very much confident when teaching Integrated Science whilst only 21% said that they were somewhat confident to less confident.

**Figure 22**

![Confidence in teaching IS](image)

*Teacher confidence in teaching IS*

About 91% of IS teachers expressed that they were very confident when teaching IS, whilst 18% indicated that they were less confident.
4.2.4 Theme 4: Challenges encountered in teaching IS

A myriad of challenges was propounded by the IS teachers. These challenges ranged from learners’ lack of motivation, resource constraints, student management, incapacitation of some IS teachers to teach particular topics, to too long a syllabus. These challenges with vignettes are presented in ensuing sections. In Table 13 the IS teachers allege that learners’ lack of motivation presents challenges as they implement the IS curriculum. This situation is identified by T22B as, “Pupils have a negative attitude towards the subject”, or “lack of interest by pupils” as seen by T71P.

Table 17
Learners’ lack of motivation

<table>
<thead>
<tr>
<th>Challenge</th>
<th>TB teachers</th>
<th>TC teachers</th>
<th>TP teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learners’ lack of motivation</td>
<td><em>It does not lend the learner to pursue it at 'A' Level and at University.</em> T05B; <em>Pupils have a negative attitude towards the subject.</em> T22B</td>
<td><em>Most of the pupils in integrated science class are not science products since those who did best were selected for pure science.</em> T52C; <em>Pupils attitude towards IS is negative because IS does not prepare them for 'A' level science.</em> T31C</td>
<td><em>Pupils sometimes do not appreciate that the aspects of IS are always applicable.</em> T72P; <em>Student exposure.</em> T74P; <em>lack of interest by pupils.</em> T71P</td>
</tr>
</tbody>
</table>

The IS teachers who specialised in Biology and Chemistry, T05B and T31C respectively, believe that students are not well motivated to learn IS because of its terminal nature, that is, it does not enable them to pursue studying sciences at Advanced Level (High school) after passing it. Whilst other reasons given for lack of motivation are the lack of appreciation by pupils of the nature of IS as said by T72P, or the nature of students as not being oriented towards Sciences as perceived by T52C. Although some IS teachers identify learner motivation as a challenge, motivation has always been perceived in literature as something which can be worked upon and improved upon and
might arguably be the role of these IS teachers to motivate their students. T05B and T31C argue however that the way IS is conceived in the education system as being terminal is in itself not motivating.

Quite a sizeable number of IS teachers have coined resource constraints as a fundamental impediment in implementing the IS curriculum. These resource constraints as tabulated in Table 14 vignettes range from reagents, apparatus and laboratory space.
<table>
<thead>
<tr>
<th>Challenge</th>
<th>TB teachers</th>
<th>TC teachers</th>
<th>TP teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource constraints</td>
<td>Theorising it without doing Practicals\T07B; lack of resources. Big classes are not easy to handle especially when doing Practicals not all pupils will not be able to manipulate apparatus.\T07B; Practicals are hindered by shortage of resources at times.\T25B; Unavailability of resources.\T12B; Lack of the laboratories.\T14B; Shortage of chemicals.\T17B; Carrying out Practicals.\T06B; resources are still limited. Time - some practical activities require more time which the time table does not accommodate.\T06B; Some shortages in science kits for practical.\T13B; Lack of apparatus. Shortage of overhead projectors and computers so that e-learning is implemented.\T02B; Teaching of topics that you cannot demonstrate practically.\T02B; the standard apparatus used at college were not available in the rural school.\T02B Most concepts are abstract and there is serious shortage of apparatus.\T18B; Lack of chemicals. Shortage of textbooks for pupils to see.\T04B; Apparatus are in adequate.\T12B</td>
<td>Experiments should take the leading role in the process of learning.\T30C; shortage of room.\T48C; Some of the pupils are disabled, they face challenges during practical experiments.\T52C; resources are lacking, you resort to theorising experiments.\T32C; Lack of resources for Practicals.\T40C; Lack of resources as there are large number of pupils.\T29C; limited resources.\T51C; Lack of resources for Practicals.\T40C; Shortage of chemicals.\T52C; Shortage of a few relevant chemicals.\T39C; Lack of sufficient chemicals to carry out experiments.\T50C; Lack of apparatus.\T34C; Lack of scientific instrument.\T52C; equipment\T39C; Lack of apparatus.\T32C</td>
<td>Big classes.\T75P; size of classes too large ranging 45 - 50 pupils\T74P; Lack of material.\T66P; Lack of resources, especially to do the Practicals needed in paper 3.\T56P; working space i.e the laboratories Physics\T54P; Lack of resources when you can't do Practicals.\T57P; can't do Practicals.\T57P; Some materials may be unavailable.\T61P; Teaching IS without experimentation.\T61P \T62P \T55P; Lack of chemicals to use in certain aspects also frustrate when teaching\T54P; Shortage of chemicals - also there is no enough working space i.e the laboratories.\T54P; Shortage of science equipment, apparatus and chemicals to carry out experiments.\T58P; Some content in some textbooks is incorrect due to misprints.\T61P; Lack of practical material.\T72P; No laboratory.\T56P; lack of laboratories. -Slow learners which can find it difficult to understand the concepts.\T62P; Inadequate laboratories.\T73P; Lack of Lab facilities.\T63P; Shortage of chemicals to carry out experiments.\T54P \T69P \T58P; chemicals required of large classes.\T73P; resources.\T74P; Shortage of science equipment, apparatus.\T58P; Repetition of experiments in theory due to lack of Practicals so that students understand in theory than performing the experiments\T59 P; lack of equipment.\T74P</td>
</tr>
</tbody>
</table>
The reagents, apparatus and laboratory space challenges are identified in all the three groupings of the IS teachers, these challenges are deemed to affect the way in which IS is taught in schools as T07B “Theorising it without doing Practicals”. Teaching IS in accordance with the syllabus requires a practical work-based approach.

Student management is another challenge encountered by some IS teachers. As expressed by IS teachers in Table 15, it seems as if these teachers are failing to manage teaching of large classes and therefore resort to “theorising experiments” as put forward by T32C.

<table>
<thead>
<tr>
<th>Challenge</th>
<th>TB teachers</th>
<th>TC teachers</th>
<th>TP teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student management</td>
<td>The teacher/pupil ratio is too large. The classes are too large hence giving the teacher a very high &quot;marking load&quot;. It becomes difficult to give pupils quick feedback. T09B; Most of the pupils we teach lack basic scientific knowledge. T14B; Some Practicals are not possible as pupils will have to work in large groups. T24B; Big classes are not easy to handle. T07B; Too big classes. T19B; T20B; T21B; Classes are too large to do Practicals in smaller groups as a result some pupils hardly participate. T25B; Practicals are not possible as pupils will have to work in large groups. T24B;</td>
<td>Large number of pupils. T29C; T40C; T37C; large number of pupils in each class of about 60 pupils. T29C; Large classes (65) which makes delivery and contact poor. T48C; The classes are very big at B School each class may have 58 pupils and there will be 5 classes of it each level. T31C; Large classes. T35C</td>
<td>large classes of about 50 to 63. T73P; The classes are so big. T75P; Mixed ability groups have a danger of a teacher moving with a small group in the end a smaller percentage becomes successful. T74P</td>
</tr>
</tbody>
</table>

Managing a large class of students as a challenge recurs in all the three groups of teachers, with T73P citing a range of between 50 to 63 students per class per teacher.
This high student to teacher ratio on the backdrop of limited reagents, apparatus and laboratory space put a lot of pressure on IS teachers.

IS teachers identified varied challenges in teaching particular topics of IS as reflected in Table 18.

<table>
<thead>
<tr>
<th>Challenge</th>
<th>TB teachers</th>
<th>TC teachers</th>
<th>TP teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to explain some topics due content level limits. T17B; Teaching formation of Cations and Anions. T02B; Learner is distanced from reality e.g. manufacture of Ammonia. T05B; I still need to be trained on how to teach the manufacturing aspect T06B; There is need to learn other sections of IS. T24B; Physics section e.g electricity Biology T19B; teaching motors and generators Biology T21B; Teaching the chemistry section of Science in Industry where explanations are based on abstract concepts. Biology T18B; Failure to explain some topics due content level limits Biology T17B; Parts of electrostatics is difficult to teach especially the Gold Leaf electroscope since it is not well outlined even in the syllabus. T24B; Learner is distanced from reality e.g. manufacture of Ammonia, sulphuric acid, Nitric acid, Electrolysis of water at Zimphos Kwekwe to include the blast furnace where tr resort to more explanation. T05B; Some practical results contradict with textbook reference. T24B; Breaking down complex/or generalising concepts. IS concepts are less detailed. T23B;</td>
<td>Science in Agriculture is too wordy revolving in same points. T31C; Teaching Generators and motors is difficult. T53C; The concept of motors and generators. T39C; Its Physics, Chemistry and Biology in one subject. Specialising makes the teacher not competent in other areas. T40C;</td>
<td>except for a few areas in Agriculture. T55P; Teaching Science in the community unit. T66P; teaching chemical related content. T74P; Teaching for exams at the expense of imparting scientific practical work. T73P; Less time to give tests and carry out experiments during the lesson. T62P; doing experiments is usually a challenge. T75P</td>
<td></td>
</tr>
</tbody>
</table>
Some teachers who specialised in Biology identified the physics and chemistry sections of IS syllabus as presenting some challenges, whilst some of those who specialised in Chemistry identified Science in Agriculture and the teaching of concept of motors and generators as challenging. Those who specialised in Physics deemed the Biology and Chemistry section of the syllabus as challenging. The teachers’ articulations of these challenges are in line with conceptualisation of Teacher knowledge and Pedagogical Teacher Knowledge in that for a teacher to be competent there should be mastery of Content and pedagogical knowledge which Shulman (1987) articulated as an amalgam of content and pedagogy. This amalgam is the one which these teachers are lacking and hence express as facing challenges. It should however be noted that most of these teachers had expressed that they had high confidents in teaching IS and maybe this confidence stems from the supposedly low content demand of IS but these teachers despite some having learnt IS at secondary school and having experienced their teachers teach IS they might be lacking the specific pedagogics to teach particular topics outside their speciality areas.

The nature of the IS syllabus was identified by IS teachers as a hindrance to the teaching and learning of IS. All the teachers in the three cohorts identified the broadness of IS as presenting challenges.
Table 19
Nature of IS syllabus

<table>
<thead>
<tr>
<th>Challenge</th>
<th>TB teachers</th>
<th>TC teachers</th>
<th>TP teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS syllabus</td>
<td>Syllabus content too broad to be covered in 6 terms. T13B; Some concepts are too abstract. T12B\T18B; Time - some practical activities require more time which the time table does not accommodate. T06B; Yes, some sections are outdated such as Engines. T16B; A lot of information assumed to be known is not known by pupils. T16B; A very long syllabus. T20B; Some concepts are too abstract especially when the apparatus are inadequate T12B; Cultural beliefs (sensitive issues) like some topics in science in the community Reproduction for instance, some traditional religious groups consider it as unfit for their children - unholy. T13B; Science in industry is just 'thrown' there when pupils do not have chemistry background. T25B</td>
<td>The area on science in Agriculture to be revamped and put in Agriculture course. This makes the syllabus easy to finish on time. T48C; covering of the syllabus. T48C; IS limits some of the concepts. T29C; Most topics are dealt with on the surface and it does not go deeper into content. T41C; Teaching IS frustrates because is a terminal science. T31C; The syllabus is too broad. T30C; Syllabus is too long T49C\T40C\T31C; The IS syllabus is very long hence teaching for exams requires completion of the syllabus. T31C; Inadequate work given to pupils because of lack of time T31C; The syllabus is too long - for two years. It does not leave time for revision. T53C; Challenges in covering the syllabus. T48C; Syllabus is too long hence some of the aspects are hurried through. T51C \T48C; Little time to fully cove the syllabus and hold remedial sessions. T48C; Lack of continuous assessment due to time constraints. T40C; The most difficult part is syllabus coverage. I find it rather too long. T41C</td>
<td>Syllabus too long. T71P; The syllabus is too long and covers a wide range of areas or sections (science in industry; agriculture; mechanical &amp; structures; community). T73P; Very little time for coverage of the long syllabus. T55P; long syllabus encompassing the practical approach. T55P; Sometimes experimental results contradict with set standard results. T58P; Time is short for completion of the syllabus. T70P</td>
</tr>
</tbody>
</table>

Some teachers deem that the breadth of the IS syllabus make the teachers rush over as they teach in order to finish teaching in the prescribed time and hence sacrificing student learning. Maybe the way in which these IS teachers teach leads towards the
time being insufficient to “covering the syllabus” as pronounced by T48C, if these teachers lack the resources to teach IS, it might mean that their approach is teacher centred which then put a burden upon them “for completion of the syllabus” as indicated by T70P and hence time becomes limiting.

The characteristics of the learners has been observed by some IS teachers as presenting challenges as tabulated in Table 20.

**Table 20**

<table>
<thead>
<tr>
<th>Learner Characteristics</th>
<th>TB teachers</th>
<th>TC teachers</th>
<th>TP teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lack of continuity of ZJC (Junior Level) content and 'O' level content. No smooth transition from ZJC to 'O' level. This is being caused by the removal of the ZJC examination. T09B;</td>
<td>Poor learner background for science. T40C;</td>
<td>Dealing with slow learners. T67P; Reducing content to levels of weak performers. T71P; Handling very slow learners with no exposure to other things. T68P; Students (most) fail in the final examinations. T55P; When students don't get a certain concept even after repeating so many times. T59P; Failure of the children to apply what they see at home and theory or Practicals they learn at school. T60P; Failure to Draw complex diagrams. T60P; Slow learners which can find it difficult to understand the concepts. T62P; time management of pupils to finish Practicals. T60P</td>
</tr>
</tbody>
</table>

The cohort of teachers who specialised in Physics identified most challenges which they attribute to learner characteristics whilst only one teacher in the Biology and Chemistry cohort perceive that learners’ background or prior knowledge of science is poor and hence the learners would not have been prepared enough to tackle Integrated
Science at Ordinary Level. The Physics specialisation cohort perceive that the learner characteristics presenting challenges is that IS learners are slow learners and hence they fail “to draw complex diagrams” as observed by T60P, “find it difficult to understand the concepts” as noted by T62P and they “fail in the final examinations” as per T55P’s conclusion.

Some teachers in all the three cohorts felt that they are not supported enough by the school administration as they implement the IS curriculum. As articulated by T73P the school administration often does not support the buying of reagents which are required for conducting practical work.

<table>
<thead>
<tr>
<th>Challenge</th>
<th>TB teachers</th>
<th>TC teachers</th>
<th>TP teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher support</td>
<td>Lack of support from the school and the parents. Some teachers think that science club or environment club they are a waste of time. Some fine opportunities to attend exchange programmes are not readily received by the SD and Heads. \T08B</td>
<td>Admin may fail to cooperate. \T31C</td>
<td>Incapable to reason scientifically by some administrators. NB; - Administrators must have also a good scientific background. \T73P; Administration support in buying of chemicals required of large classes. \T73P</td>
</tr>
</tbody>
</table>

Beside lack of support from the school administration, T08B indicated that parents through the School Development committee (SDC) should support “fine opportunities to attend exchange programmes” which enable the teachers to upgrade themselves through observing how other science teachers conduct themselves.
Some Chemistry and Physics IS cohort teachers felt that the teachers’ content knowledge was presenting challenges. Teaching of such topics as Science in Agriculture, Science in the community presented challenges for T41C and such that he had to rely on Ordinary Level knowledge which he learnt years back in order to teach these topics.

Table 22

<table>
<thead>
<tr>
<th>Challenge</th>
<th>TB teachers</th>
<th>TC teachers</th>
<th>TP teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Content knowledge</td>
<td>I rely on my ordinary level knowledge of science to teach IS. T41C; I have to research especially in order to teach science in the community. T41C; Science in agriculture and community are difficult to teach T49C; Sewage treatment is difficulty to teach T49C; need for one to major in the three areas namely physics, chemistry and Biology. T31C; Rely on my experience. T51C</td>
<td>Trying to simplify the required information to simple O-Level standard. T67P; Simplify information to the level required by IS. T68P; teaching IS requires practical skills. T57P; Dealing with slow learners. T67P</td>
<td></td>
</tr>
</tbody>
</table>

T67P and T68P of the physics cohort on the other hand felt over qualified to teach IS in such a way that they find it difficult to simplify their knowledge to the level of the learners. T67P found it challenging to teach the “slow learners taking IS”.
4.2.5 Theme 5: Most enjoyable when teaching IS

IS teachers were asked to indicate what they most enjoy when teaching IS and their indications appear in Table 23. Some IS teachers in all the three cohorts said that they take delight when teaching IS in the multidisciplinary nature of IS, the teaching approaches they employ, teaching specific IS topics, the product of their teaching and the demands of the IS syllabus. Teaching through practical work is identified in all the three cohorts of IS teacher as enjoyable. This however contradicts with the teachers’ earlier assertion that they do not carry out practical work because of lack of reagents and apparatus. Maybe the teachers are referring to the sparse occasions in which they are able to undertake some practical work.
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>TB cohort</th>
<th>TC cohort</th>
<th>TP cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multidisciplinary</td>
<td>it is a multidisciplinary subject exposing teacher and learner to a broad spectrum of bodies of knowledge Physics, Biology and Chemistry.\T05B; relevance in the community.\T13B</td>
<td>Applicability.\T34C</td>
<td>Most of the learning experiences are related to children home experiences.\T60P</td>
</tr>
<tr>
<td>Teaching approach</td>
<td>the practical part of it because pupils discover things on their own being guided by the teacher and this helps them to grasp concepts taught.\T07B; Practicality.\T12B \T13B; carrying out experiments.\T04B; Bio lab techniques - it stimulates interest of pupils as they acquire practical skills.\T06B; Discovering with the pupils in Practicals.\T16B; Bio lab techniques.\T06B; Discovering with the pupils.\T16B</td>
<td>Being a practical instructor.\T52C; Use of active teaching and learning methods e.g. games.\T40C; The practical work.\T48C; The social thrust aspect of IS is the most enjoyable when teaching the subject. Examples of links to community abound e.g. Sable chemical Industries, ZISCO steel, Mhangura mine etc. it really sows a connection between Science and our own country.\T41C; The experimental part of IS.\T30C; When I carry out demonstration and when students are carrying out experiments.\T50C; carrying out experiments.\T32C</td>
<td>Demonstration easily done &amp; pupils understand.\T71P; teaching of practical/experimental activities.\T54P; Doing practical with pupils.\T57P; When pupils conduct an experiment and produce the desired and the expected results.\T58P; Experiments.\T62P.\T61P; Practical work.\T75P; Proof of hypothesis by experimentation.\T61P</td>
</tr>
<tr>
<td>Teaching specific topics</td>
<td>I enjoy teaching the section structures and mechanical systems because most of the materials required are found within the school.\T18B</td>
<td>The chemistry sections and Models and bridges.\T38C; I enjoy teaching chemistry. To me nothing is very difficult in teaching IS.\T51C; The practical work in science in structures makes me feel happy in teaching science. Mostly of copper.\T48C; Teaching Industrial processes.\T37C; Science in community is enjoyable.\T53C; practical work in science in structures.\T49C</td>
<td>Teaching the topic Energy uses.\T66P; Normally science in Industry is more enjoyable.\T70P; When teaching biology lessons i.e. living things.\T74P;</td>
</tr>
</tbody>
</table>
### Table 21 (continued)

**What IS teachers most enjoy when teaching IS**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>TB cohort</th>
<th>TC cohort</th>
<th>TP cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teaching product</strong></td>
<td><em>If pupils I am teaching, become scientific minded and come up with scientific projects to betterment of the environment and society.</em>&lt;sup&gt;T08B&lt;/sup&gt;; <em>When pupils grasp the difficult and most abstract concepts.</em>&lt;sup&gt;T09B&lt;/sup&gt;</td>
<td><em>appreciation of scientific concept after coming out with positive result.</em>&lt;sup&gt;T52C&lt;/sup&gt;; <em>Negative result also help to find possible sources of error.</em>&lt;sup&gt;T52C&lt;/sup&gt;</td>
<td><em>When students learn something new, and they understand it so well and appreciate the new knowledge.</em>&lt;sup&gt;T59 P&lt;/sup&gt;; <em>The outcomes. When pupils identify the application of science knowledge to their day to day activities.</em>&lt;sup&gt;T55 P&lt;/sup&gt; <em>I enjoy getting my students to understand science.</em>&lt;sup&gt;T55 P&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Syllabus demands</strong></td>
<td><em>The most enjoyable part is its shallowness hence many lessons may proceed unprepared thoroughly.</em>&lt;sup&gt;T31 C&lt;/sup&gt;</td>
<td></td>
<td><em>Everything is enjoyable.</em>&lt;sup&gt;T69 P&lt;/sup&gt;; <em>Nothing difficult to teach.</em>&lt;sup&gt;T69 P&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**4.2.6 Theme 6: Instructional strategies used by IS teachers**

Although some IS teachers have proffered practical work as the most enjoyable and preferred instructional strategy when teaching IS, they however also identified other teaching approach which they use as indicated in Table 23.
### Table 23
**Instructional strategies used IS**

<table>
<thead>
<tr>
<th></th>
<th><strong>TB cohort</strong></th>
<th><strong>TC cohort</strong></th>
<th><strong>TP cohort</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Guided discovery methods</td>
<td>T13B, T07B(2)</td>
<td>T41C(1)</td>
<td>T63P(1)</td>
</tr>
<tr>
<td>Field excursions</td>
<td>T18B(1)</td>
<td>T32C(1)</td>
<td></td>
</tr>
<tr>
<td>Demonstrations</td>
<td>(0)</td>
<td>T34C, T50C, T51C, T52C, T38C(5)</td>
<td>(0)</td>
</tr>
</tbody>
</table>

Despite citing the inadequacy of resources for carrying out practical work, IS teachers indicated practical work as the most used and preferred teaching strategy, with 44% of T#B teachers, 31% of T#C teachers and 29% of T#P teachers within each cohort citing that they use practical work in teaching. The Integrated Science syllabus guidelines however put an emphasis for teachers to provide pupils with practical experience. A sizeable number of teachers use lecture method, 26% for teachers who specialised in physics, 14% for teachers who specialised in chemistry and 31% for those who specialised in Biology despite the syllabus’ guidance to use child centred instructional strategies.
4.2.7 Theme 7: Important scientific ideas which IS students should learn

IS teachers were interrogated on scientific ideas which they felt students should learn at this level and their views are tabulated in Table 24.

<table>
<thead>
<tr>
<th>Science concepts</th>
<th>TB cohort</th>
<th>TC cohort</th>
<th>TP cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology – e.g nervous system</td>
<td>T19B, T20B, T31C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science in community</td>
<td>T20B, T13B, T12B, T21B, T19B</td>
<td>T53C</td>
<td>T74P</td>
</tr>
<tr>
<td>Digestion</td>
<td>T24B, T12B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Genetics</td>
<td>T24B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science in Agriculture</td>
<td>T21B, T24B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science in Industry</td>
<td>T13B, T17B, T24B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biotechnology</td>
<td>T16B, T23B, T24B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indigenous Knowledge</td>
<td>T14B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health and diseases</td>
<td>T24B</td>
<td>T37C</td>
<td></td>
</tr>
<tr>
<td>Chemical equations stoichemistry</td>
<td></td>
<td>T31C,</td>
<td>T67P, T70P, T63P</td>
</tr>
<tr>
<td>Science in structure</td>
<td>T48C, T29C</td>
<td>T66P</td>
<td></td>
</tr>
<tr>
<td>Prior science knowledge for A-Level</td>
<td>T52C, T38C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classification of living things</td>
<td>T49C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction kinetics</td>
<td>T50C</td>
<td>T68P</td>
<td></td>
</tr>
<tr>
<td>History of science e.g. Archimedes, Newton, Boyle Faraday.</td>
<td></td>
<td>T73P, T63P</td>
<td></td>
</tr>
<tr>
<td>Kinematics</td>
<td></td>
<td>T66P, T67P</td>
<td></td>
</tr>
<tr>
<td>Electronics</td>
<td>T61P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring scales</td>
<td></td>
<td>T60P</td>
<td></td>
</tr>
</tbody>
</table>

It can be noted in Table 24 that IS teachers in each specialisation cohort mostly suggested as important areas which should be learnt those concepts in their area of
specialisation e.g. those who specialised in Chemistry education suggested mostly Chemistry concepts serve for T31C and T53C. The physics education specialisation cohort indicated in addition that some chemistry concept were also important concepts. It seems that although these teachers are teaching Integrated Science, their area of specialisation remains a major influence in the decision they make in the classroom, what they deem as important in student learning is based on their area of specialisation.

4.2.8 Theme 8: Suggested changes to IS curriculum

Some IS teachers felt that the Integrated Science curriculum has to change. Despite having indicated that IS syllabus is rather too long for the two years in which it should be learnt, some IS teachers mostly from biology specialism still suggested that there is need to add some concept which they felt were an important aspect of student learning. However, those teachers in the chemistry specialism and some in the physics specialism felt that there was need to reorganise the whole ordinary level curriculum in such a way that some IS content are moved to other subjects such as Agriculture and Geography. This might be an indication of the underlining unpreparedness of these teachers to teach the content they had not learnt at college. All the change suggestion vignettes appear in Table 25.
## Table 25
Suggested changes to IS curriculum

<table>
<thead>
<tr>
<th>TB cohort</th>
<th>TC cohort</th>
<th>TP cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>- They should learn reading peaks of waves on visual display and interpret data in chromatography and soil sampling.\T05B</td>
<td>- The area on science in Agriculture to be revamped and put in Agriculture course. This makes the syllabus easy to finish on time.\T48C</td>
<td>- IS is currently too general in some aspects. There is need to treat the pure sciences (Physics, Chemistry &amp; Biology) more deeply in the science teacher education programme and correspondingly change the school curriculum to treat the same sciences more deeply than is done at the moment.\T61P</td>
</tr>
<tr>
<td>- To utilise resources from the environment to make things for learning (for science exp.). To be able to replace for example a bulb and to be able to conserve the resources which are found in the environment.\T07B</td>
<td>- Emphasis on practical approach is where pupils could write a practical rather than an alternative to practical as this will improve their science skills.\T29C</td>
<td>- I think the curriculum should be revamped to match modern scientific demands.\T67P</td>
</tr>
<tr>
<td>- The IS curriculum is too long. The part on engines, and some part on science in structures-Beams etc should be removed.\T12B</td>
<td>- IS Curriculum should be revamped to meet 21st century skill requirements.\T41C</td>
<td>- Equations of motion should also be included at most as far as Newton's second law of motion.\T63P</td>
</tr>
<tr>
<td>- There are some basic concepts esp. on structure of atoms that were omitted which are instrumental in the understanding of other concepts. (Formation of Cations and Anions).\T02B</td>
<td>- Population studies should be offered in geography.\T31C</td>
<td>- Include Technology and science advancement.\T74P</td>
</tr>
<tr>
<td>- Extraction of minerals from the soil to be added.\T06B</td>
<td>- They should do away with alternative to practical papers which lead to most teachers theorising Practicals.\T32C</td>
<td>- Include importance of science &amp; Lightning struck.\T62P</td>
</tr>
<tr>
<td>- Yes, some sections are outdated such as engines.\T16B</td>
<td>- No curriculum changes.\T34C</td>
<td>- History of prominent scientists &amp; industry and industrialisation to be added\T74P</td>
</tr>
<tr>
<td>- The practical use of learnt concept to implement change in the society. E.g. leading clean-up campaign and public awareness on conservation, using concepts learnt from the &quot;Science in the Community sections&quot; or create employment by implementing ideas learnt in the science in industrial or science in energy, coming up with projects on alternative sources of energy.\T08B</td>
<td>- \T29C \T31C</td>
<td>- Biological make-up of living things and components.\T74P</td>
</tr>
<tr>
<td>- I believe that for the IS to be relevant in the society, pupils must develop manipulative skills and gain confidence in the practical work they do so that they gain confidence in the practical work they do so that they can contribute to the society. I assist pupils with the models for the SEITT competition to promote initiative.\T08B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Yes there is need for a change. There is need to include ICT in integrated science teaching.\T09B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Include the skeletal system\T09B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2.9 Theme 9: Reforming Teacher Education Curriculum

On being asked on the need for changing the teacher education curriculum, some IS teachers gave indications on what should change whilst a few felt that the status quo should be maintained. Table 26 contains vignettes responses to the interrogation on what changes should be infused into Science Teacher Education curriculum.
### Table 26

**Suggested changes to Science Teacher Education curriculum**

<table>
<thead>
<tr>
<th></th>
<th>TB cohort</th>
<th>TC cohort</th>
<th>TP cohort</th>
</tr>
</thead>
</table>
| **e-learning integration** | - There is need to integrate e-learning in the training of teachers. \T02B  
                      - Need for improvement in the use of ICT. \T20B  
                      - National and school syllabi, District and Provincial science panels, refresher courses; revised methodologies from the internet; In-house trainings, upgrading self. \T13B | - Intensify the use of information technology aspects such as overhead projectors, whiteboards, computer simulations. Not just talk about them. \T39C | - Yes- introduce more technologically linked aspects. \T55P  
                      - The curriculum should include computer-based technologies. \T67P  
                      - Curriculum to include IT & computer-based technologies. \T68P |
| **Practice Teaching** | - There is more to learn in practice than at college. \T16B  
                      - The preparation to teach received at college was not comprehensive because of lack of teaching experience. After gaining experience my teaching of IS became easier. \T09B | The teaching practise offers real life experience at work. \T31C  
                      - The knowledge required to teach IS in practice is great and crucial. One has to do what is on the ground so as to suit a scenario as some theories won't work. \T48C | |
| **Teaching methodologies** | - management of the teaching process. \T06B  
                      - Yes - use of active teaching methods. \T30C  
                      - Child centred approach and use of active learning resources. \T40C | To understand classroom management. \T62P | |
| **Teacher Education general concerns** | - Most concepts that I learnt at University during my Biology study period do not apply to IS sometimes they seem too complex to meet the requirements of IS. \T23B  
                      There is emphasis on coming up with projects and submission for assessment. \T08B | - College preparation was insufficient. Not related. \T35C  
                      - No strong relationship. \T38C | - Yes. Empirical by not emphasising examinations. Aspects include culture, morals, folklore beliefs. Does not necessarily go hand in hand as information is at the level of the pupils especially if required to teach. \T73P  
                      - Yes. \T56P \T57P \T62P  
                      - Some of the things were not taught Some of them but not all. There was not much of link with IS since the things taught at college were not relevant to IS. Inclusion of Indigenous knowledge. \T56P  
                      - Some of them not all. \T60P |
### Table 25 (Continued)
**Suggested changes to Science Teacher Education curriculum**

<table>
<thead>
<tr>
<th>Practical work</th>
<th>TB cohort</th>
<th>TC cohort</th>
<th>TP cohort</th>
</tr>
</thead>
</table>
|                | - There is need to change; teacher education curriculum should in-cooperate more of practical work rather than content. More time seemed to be dedicated to non-practical work. A change is needed even on the exam, more questions should be practical questions. \( T13B \)  
- There was less practical work done at college then than I did at secondary level. \( T18B \)  
- Yes science teacher education should focus more on the practical aspect of science teaching so as to equip pupils in schools with adequate psychomotor skills. the emphasis is still on theoretical approach - there is need to transform the approach and adopt the practical one so as to improve IS teaching. \( T06B \)  
- The training at college level and university has a lot of practical work which at times is difficulty to find/do when teaching IS. Practicals are hindered by shortage of resources at times. \( T25B \)  
- Trs on the training should be taught to improvise apparatus. Formation of Cations and Anions. \( T02B \)  
- Yes. The science teacher education curriculum should be more of carrying out experiments, practical work and less theory, i.e. verification of experiments, improvements and varying of the experiment, especially from the use of conventional apparatus to using locally available apparatus. | - Yes. Focus more on the practical aspect i.e. more TP than at college. At college/university- more theoretical and advances or sometimes divorced and less practical. \( T34C \) | - There is need to change the science teacher education because it is more of academic than practical. At college we were taught the methodologies, teaching IS requires practical skills. \( T57P \)  
- Yes. Science trs need hands on practice and skills while they are undergoing training so that they apply this when they are deployed. \( T58P \)  
- The science teacher curriculum must be changed. Pupils must have more practical work than theory this means Practicals must contribute to the student's final exam mark. \( T75P \)  
- Make teachers more aware about experimentation during the lesson. How to carry out experiments. How to conduct experiments with large group. \( T62P \) |
<table>
<thead>
<tr>
<th>TB cohort</th>
<th>TC cohort</th>
<th>TP cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No need for specialisation</strong></td>
<td>More still, science teachers should not major in certain areas; they should be conversant with all science areas unlike training and specialising since most teachers seem to be useful in one area but somehow useless in other important areas of science.</td>
<td>-It is not right to start specialising at the on start. Specialisation only comes later but for IS teachers should do all the sciences like some colleges do. Need to read further than what is done in college and adapt the knowledge to the different student levels.</td>
</tr>
<tr>
<td>-IS should at least be introduced at high and tertiary education i.e. in universities such that teachers are effectively trained on the subject.</td>
<td>-There should be no specialisation all student teachers should learn Physics, Chemistry and Biology.</td>
<td>-each teacher get specialised to the subject content s/he is to teach. An example is a teacher should specialise in one subject e.g biology, chemistry, physics e.t.c.</td>
</tr>
<tr>
<td>-IS teachers must do Physics, Chemistry and Biology on their first year at college or university the specialise later.</td>
<td>-There is need for a science teacher to be trained in all sections of science in order for him/her to be able to teach IS.</td>
<td></td>
</tr>
<tr>
<td>Chemistry doesn’t aid much since its focus is ‘A’ Chemistry or “O” Chemistry pure.</td>
<td>-The curriculum should fit the content and aspects of integrated science since some of the concepts are not well explained in areas of specialisation.</td>
<td></td>
</tr>
<tr>
<td>University preparation is 75% (approximately) of the knowledge required for teaching IS. There is need for a science teacher to be trained in all</td>
<td>-University preparation is 75% (approximately) of the knowledge required for teaching IS. There is need for a science teacher to be trained in all</td>
<td></td>
</tr>
<tr>
<td>-There is need to change science teacher education curriculum when it comes to IS tr training. Some trs perform badly when it comes to teaching Physics or Chemistry topics. In fact, when recruiting consider when one has done physics, chemistry or biology or physical science and biology at O-Level, not just integrated science.</td>
<td>-There is need for majoring in the three areas namely physics, chemistry and Biology. Maintaining science methods exposes the teacher to correct interpretation of syllabus.</td>
<td></td>
</tr>
<tr>
<td>-There should also be a course in Biology when doing BScEd degree.</td>
<td>-The content provided at college mainly for those who teach IS link but not clearly. Face challenge in Fuels and engines.</td>
<td></td>
</tr>
<tr>
<td>-Some aspects of Biology were lacking though most of knowledge I acquired at University enables me to teach integrated science.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
IS teachers raised indications on the need to integrate e-learning, put more emphasis on practical work, revise the teaching methodologies taught and avoid specialism when preparing teachers for IS teaching.

Figure 23

The need to learn through practical work was sighted as paramount in changing teacher education curriculum together with integration of e-learning.

Some teachers felt that there was no need for changing the Teacher Education Curriculum citing diverse reasons which appear in Table 27.
T61P and T41C felt that IS content is too shallow as compared to what is learnt at college and hence the teacher would ordinarily be able to teach this shallow IS content. Maybe what T61P and T41C might be missing is how that “shallow” IS content should be packaged by content ‘rich’ teachers for their student to learn.
33%, 31% and 21% of IS teachers who specialised in Physics, Biology and Chemistry respectively felt that their particular area of specialisation was relevant when teaching IS. Only 10% of IS teachers held the view that specialisation should not be done at college.

4.3 Analysis of the Interview responses

The semi-structured interview findings are presented in a narrative array arranged by the first level of coding; each participant’s experiences relating to the themes that emerged as a result of the second level of coding, engagement and relationships are highlighted within these themes.

4.3.1 Theme A: About education background of the respondents

Demographic information of the interviewees is presented on Table 28. This was necessary to validate the information already gathered by the researcher for purposes of possible later engagement with the participant. This was also a way of affirmation as
well as ensuring as much diversity as possible of the congregated teacher participants of varying years of experience and specialism.

The interview participants had studied science at Ordinary level and some had also proceeded to do Advanced Level science.

Of the participants noted in Fig. 17, 67% held only a diploma in science education (Dip.Sci.). Of those with Biology specialism only one teacher had only a diploma in education, two teachers from Chemistry specialism held a Dip.Sci. whilst all the three teachers from the Physics specialism held a Dip.Sci.. Three teachers had higher qualifications making up 33%, one from the Biology specialism was a holder of a bachelor in Science degree (BSc.Ed.), another one from the Chemistry specialism a certificate in education and BSc.Ed., whilst the third one from the Biology specialism had a Dip.Sci. and a Bachelor in Science Honours degree in Education (H.BSc.Ed.).
Of the interview participants noted in Fig. 25 all deemed sufficiently experienced with the least experienced being T06B and T52C with two years of post-qualification teaching experience, T07B and T54P had three years, T61P had four years, T13B had seven years, T31C and T74P had each ten years of experience, whilst the most post-qualified experienced teacher was T48C with thirteen years.

Influence of educational background on teaching IS

Upon being asked on how their educational background impact on the teaching of IS, the research participants’ responses were varied as indicated in Fig. 26.
The participants’ chose to emphasize varied educational backgrounds which had a direct impact on how they teaching IS. The participants from the Biology education specialism cohort indicated that the knowledge which they acquired from college had a direct effect on the way they teach IS. One participant of this group referred to this knowledge as Biological knowledge, another one called it content knowledge whilst another view which popped-up from this cohort was that the first year of college before specialisation was important for an important stage for preparing to teach IS.
The chemistry education cohort had some concurrence with the Biology cohort in so far as to say that college education was an important preparation which enabled them to teach IS in a better way, however, all IS teachers of this cohort went on to say that Chemistry which they learnt was of immense import when they teach IS. One teacher from this cohort said that he was grateful of the training received from college because through this knowledge he was able to manage the teaching and learning process.

The emphasis of the answers given by the Physics cohort was on the ability to manage the teaching and learning process, and also being skilful and innovative when delivering the IS lessons due to the knowledge they received from college. On being asked on how the content from the physics area of specialisation impacted their teaching, one member of this cohort said, “Physics as a subject matter has little if any use when teaching IS. Rarely do I use the concepts which I learnt at college to in delivering the IS lessons”.

4.3.2 Theme B: About teaching background

At the time when this data was collected the IS teacher participants ranged in their teaching load from three classes per term to 7 classes per term. All the nine interviewed teachers were teaching IS and had been doing so since the time they graduated. The three teachers from the Biology specialism were also taking Biology in addition to IS, two teachers from the Chemistry specialism were also taking Physical Science on top of IS whilst two from Physics specialism were taking Mathematics as well as IS, as illustrated in Figure 29.
The range of teaching years the participant IS teachers have was deemed enough to categorise them as experienced teachers. With experience there is a high probability of getting valid answers to the questions posed.

4.3.3 Theme C: About IS student learning

T13B perceived that, “students at Forms 3 and 4 learn through practical work that is directly relevant to our day to day life in form of manufacturing or industrial practical experiments”. He also articulated that “guided discovery method and homework also enhances effective learning and is better than rote learning”. For T07B, “utilisation of the environment to make things for learning as well as peer teaching and use of the internet resources facilitate student learning at Ordinary Level”. T07B also concurred with T13B in that, “engaging in practical work, giving Homework and assignment for the pupils to research enable them to learn IS”. As well, T06B also felt that,
“experiments, field visits, observations, practical activities and tests are crucial strategies which facilitate learning of IS”. Some of the ideas about teaching and learning raised by the IS teachers in this cohort have also been raised by Bartholomew, Osborne, & Ratcliffé (2004). Bartholomew, Osborne, & Ratcliffé (2004, p. 678) articulates that

Effective teaching of “ideas-about-science” requires establishing a context in which it is possible for students to engage in reflexive epistemic dialogue…For many years teachers have been encultured in the habitus of traditional science teaching, this could require a shift in conception of their own role of dispenser of knowledge to facilitator of learning; a change in their classroom discourse to one which is more open and dialogic; a shift in their conception of learning of the learning goals of science lessons to one which incorporates the development of reasoning and an understanding of the epistemic basis of belief in science as well as the acquisition of knowledge; and the development of activities that link content and processes in tasks whose point and value is transparent to their students.

Albeit identifying practical work as crucial in student learning, T06B highlights that at his school resources are limited, there is not enough time allocated on the time-table to conduct these practical activities and also that he still needs to be trained to conduct some experiments which lie outside his area of specialism like those which have to do with the “manufacturing aspect”.

T61P feels that, textbooks, information from industries, television programs and seminars as well as experimentation using available resources facilitate student learning. He goes on to emphasize that, “pupils understand more when they do experiments on their own through handling materials”. He however, is frustrated that at his school some apparatus and reagents are not available for conducting experiments and those experiments are not done like for example, “the series of experiments on photosynthesis in the Science in Agriculture section”. T54P concurs with T61P that “the available textbooks as well as the internet allows the gathering of information which
facilitate student learning”. For T74P, as IS is a “shallow subject content-wise”, he is of the opinion that, “writing notes on the board, oral class discussion and teacher expositions is a practical way of facilitating learning of IS considering that each class range from 45 to 50 pupils and shortages of resources and time limitations”.

“The internet, the community in which the school is located and use of real life examples like dry distillation of wood at Wattle Company Estates, are ways which facilitate student learning” according to T31C. T31C indicated that most of his lessons are teacher centred although sometimes pupils work in groups. This scenario according to T31C, “is due to the fact that the syllabus is too long hence I teach so as to complete the syllabus such that as the students write the national examinations they will not complain that they did not cover some sections of the syllabus”. In echoing T74P, T31C also pinpointed that, “IS is shallow hence as an experienced teacher I proceed in conducting most of the lessons without preparing thoroughly”. According to T52C, “making use of real life examples, practical experiments as well as ZIMSEC question papers enable the pupils to apply the concepts effectively”, and hence facilitates student learning of IS. T52C however, point out that “lack of scientific instruments and chemicals” militates against the conducting of experiments at his schools and hence most experiments are not done. T48C revealed that he facilitated the learning of IS through “improvisation especial during the teaching of the section Science in Structures”. Besides improvisation, T48C also said that he engaged with students in, “discussions, group work, expositions and some little practical work due to shortage of room and time to cover the syllabus”. For T48C large classes makes lesson delivery and students contact poor.
The research participants identified varied content areas they felt the student should learn as part of IS. T61P felt that students should be taught, “electronics starting from Form 3 level for the country (Zimbabwe) to be able to produce at least her own electronic devices to cut down on imports”. T74P was of the idea that, “IS students should learn about natural resources and their importance, technology and science advancement history of prominent scientists, biological make-up of living things and components, and industry and industrialisation. T54P felt that IS should be about, “nature and proving hypotheses”.

T06B was of the idea that IS content should be on, “extraction of minerals from the soil, manufacturing of machines such as cars, wheelbarrows and farm implements using extracted metals, growing of crops and management of diseases and pests, construction of structures (Trusses) and assemblage of machines and mechanical systems”. What T06B perceived should make up IS is what is already part of IS except for such aspects as detailed study of the process of photosynthesis. T07B held the view that, “IS students should be able to utilise resources from the environment to make things for learning, to be able to replace for example a bulb and to conserve the resources which are found in the environment”. T13B opines that IS should be about, “learning what is directly relevant to the students’ day to day life in the form of manufacturing or industrial Practicals/experiments”. What IS teachers with a Biology specialism background opinionated resonate around IS that is utilitarian, that assist the students to acclimatise within their existential ambient.

For T48C, “IS should be about students exploring more on what they know most and be rewarded for that because some students are good at Science in Structures and they
should learn more about this section”. What T48C is suggesting is that the students should be given an opportunity to specialise within the IS syllabus at the same time living out some section of IS which they hold no interest in. T52C perceived that, “all concepts that prepare for science and technology at Advanced Level should be a part of IS”. T52C further clarified that some of these concepts are not part of the current IS syllabus and hence should be integrated into this syllabus so that IS ceases to be a terminal science subject. T31C is however more precise than T52C, identifying content areas which should be part of IS such as, “the stoichiometry part in Science in industry, and equations (chemical), Biological sections such as nervous system and removing topics on sewage and population studies offered in Geography”. These concepts appear in the Advanced Level science curriculum.

The research participants indicated that there is no obligation within their school station to embark of school wide assessment of IS serve for convenience. According to T06B, “When one teacher is taking all the classes at the same level say at Form 3 level with 5 classes that teacher may decide to give all the classes the same assessment question items or different assessment items and when two teachers are involved, each teacher may decide to give a different assessment protocol”. The IS teachers concurred that the only time when students are obligated to sit for the same assessment protocol is at the end of Form 4 when they write their ZIMSEC examinations.

Theme D: About IS teacher critical classroom experiences

Most teacher participants (6) percieved that they did not find any bliss when teaching IS. T74P attribute this lack of enjoyment to what he considers as the shallowness of IS as a subject. On the other hand T06B, T31C, T48C, T54P & T61P percieve that the
“little support” offered by the school make the teaching of IS not to be joyous. This lack of support is said to be manifesting its self in lack of teaching and learning resources (T48C, T61P & T54P). T61P also pointed out that some textbooks have have incorrect content due to misprints and to him this was a major concern as will dedicate more time to assist his students to unlearn these misprints. T31C pointed out that IS pupils have a negative attitude towards the subject “because the subject does not prepare them for Advanced Level studies”. T06B felt that besides the limited teaching and learning resources, limited time allocated to IS on the time-table affected the teaching of IS as “some practical activities require more time and will not be accommodated by the time-table”. T06B went on to reveal that he had some “content deficiency” as he aptly put it, “I still need to be trained on the manufacturing aspects so as to produce productive pupils”. Two thirds of IS teachers from the Biology specialism however, percieve that they derive joy in teaching IS. Maybe this is due to the fact that most IS content is basically biological in nature.

**Figure 27**

*Deriving enjoyment in teaching IS*
On being asked on what students need to learn about science at Ordinary level, all research participants proffered that the IS curriculum should be adjusted. They put forward varied knowledge areas which they perceive as important. T06B opined that practical skills are rarely taught but these enhance hands on experience and also that there should be teaching for greater understanding of concepts through experiments, field visits, observations, practical activities and tests. According to T06B, extraction of minerals from the soil, manufacturing and assembling of machines such as cars and farm implements using the extracted metals, construction of structures such as trusses, growing of crops and management of pests and diseases should be included in the IS curriculum. However, T07B was of the opinion that IS teachers should rely on the environment to facilitate learning. As part of IS students should learn basic day to day things and also they should learn how to conserve resources which are found in the local environment through giving students assignments and homework according to T07B. Echoing T06B, T13B articulated that IS students should learn practical work that is directly relevant to our day to day life like manufacturing or industrial Practicals/experiments through guided discovery methods-homework and practical work as this enhances learning and is better than rote learning. IS teachers from the Biology specialism were promulgating for minor reforms in IS curriculum, specifically related to the better implementation of the curriculum that is teaching through practical work and aligning the IS content to the immediate student environment.

T52C held the view that all concepts that prepare for learning science and technology at Advanced Level should be part of the IS syllabus. IS concepts according to T52C should be learnt through making use of real life examples, practical experiment and past examination papers so that pupils will be able to apply the concepts effectively as
recommended nationally. Whilst T48B on the other hand held the view that students should learn “IS sections which they are good at and which interest them e.g. science in structures through discussions, group work, expositions and a little of practical work as there is very little time available to cover the current IS syllabus”. In other words, T48C is of the opinion of cutting down on IS content through allowing students to select options in which they specialise. T31C also support the cutting down of IS content as suggested by T48C but in the Biology sections where such topics as Sewage and Population Studies offered in Geography should be removed. TC31C also pointed out that “the classes are very big at my school; each class may have 58 pupils and there will be 5 classes at each level.” This situation according to T31C leads to, “giving inadequate work to pupils because of lack of time on the part of the teacher.” T48C suggested for the addition of the topics nervous system for the Biological Sciences section and stoichiometry for Science in Industry as well learning of Chemical equations. If the syllabus remains long as it is the best teaching approach is “teacher centred way of teaching, though here and there pupils work in groups”. T48C concurred with T31C that there was “little time to cover the syllabus and hold remedial sessions. Large classes make the delivery and contact poor.” IS teachers holding Chemistry specialism were general of the opinion that the IS curriculum is too long and should be trimmed.

T74P discoursed that IS students should learn about “natural resources and their importance, technology and science advancement, history of prominent scientists, biological make-up of living things and components, industry and industrialisation” as opposed to the current curriculum as these aspects enable the students to fit in a globally world. For T74P if the class size remains 45-50 students, oral class discussions and
teacher expositions is the only best way to teach IS. T61P proffered that students should “produce things after learning IS and not only being theoretical”. He identified Electronics as an important concept which should be learnt and in learning this concept the students should produce at least their own electronic devices in order to cut down on import costs. T61P identified experimentation using available apparatus as a way to facilitate learning. T54P said that Science is all about nature and it should aim to prove hypotheses. T54P was of the view that Practical work is the best instructional strategy for teaching IS. IS teachers holding a physics specialism seem to be of the view that a change in IS curriculum should be inclined towards industrialisation and basic science studies.

IS teachers perceive their roles in IS learning as; lesson planning (T07B; T13B), lesson delivery (T13B), lesson assessment and evaluation T13B), teaching (T61P; T54P, T74P; T52C; T31C), covering the syllabus through lesson delivery, holding remedial lessons (T48C), controlling and managing the teaching process, being stuck in front of the pupils so as to implement and evaluate IS effectively (T06B).

**Practical work in IS as a critical classroom experience**

Engagement in practical work was raised as a key classroom experience by the participants. T06B applauded the carrying out of experiments as way in which interest of the pupils to study IS may be stimulated as the students acquire practical skills. T48C however retorted that, “due to shortage of rooms and in order to cover the syllabus, as well as amusing the education officials I rarely conduct practical work though sometimes I improvise when teaching Science in Structures and this makes me happy”. T52C appreciated “practical experiments” as being “key as they facilitate application
of learnt concepts by students though some physically disabled students encounter challenges when carrying out these experiments”. Lack of scientific instruments and chemicals however deter T52C from employing practical work as a teaching strategy.

T74P believes that as students sit an Alternative to Practicals paper as a final examination it “makes teaching through experiments futile”. Although T74P treasured experiments, he however chose a realistic way of teaching since he has to “prepare students for an examination which does not involve experiments”. It seems as if T74P’s main teaching goal is only to prepare for examination instead of facilitating student learning. T74P revealed that he “rarely used experiments when teaching IS because the classes were too big with around 50 students each”. T74P went on to pose a question, “How can one manage such classes in a laboratory?”. T54P conceded “I sometimes teach IS through practical work and I enjoy it, I could do this often but there are always shortages of chemicals and also there is not enough student working space in the laboratory”. T61P also revealed that he employed “experimentation in teaching IS whenever possible” and pupils understood more when they do experiments on their own, handling materials. However, at T61P’s work station some materials are often not available for carrying out experiments and this frustrates him a lot.

T13B employs practical work that is directly relevant to his “students’ day to day life in the form of manufacturing or industrial processes as this enhances effective learning and is better than rote learning”. On the other hand, T07B stated, “in these schools like mine we rarely carry out experiments as there are no resources. I am aware that practical work makes pupils discover things on their own being guided by the teacher and this helps them grasp the concepts”.
On being asked on which resources they mostly rely on when teaching IS about 78% (7 out of the 9) of the IS teachers indicated their over reliance on chart diagrams, with T52C articulating this as, “the chart diagrams can be used year in year out and in these days of limited resources they are the only feasible teaching aids”. T06B and T13B however did not identify charts as an important teaching aid, they indicated that they relied more on nature for carrying out Practical Work. T06B said, “I often use potted plants and sometimes go on excursion with my students so that they learn such things as, factors affecting photosynthesis, hands on”. Besides relying on nature T13B also indicated that textbooks were an important aid in teaching IS, whereby he would give the pupils some textbook based tasks and the students work on these tasks in groups as well as individually.

IS teachers in the Physics specialism cohort felt that IS is an “elementary science, which lacks complexity”-T61P such that the teaching of IS is not demanding to the extent that T74P says, “I do not prepare for IS lessons, I just go and teach. It is a shallow subject content-wise”. Maybe this is the reason why these teachers rely too much on charts and do not take time to explore other ways of teaching IS besides teacher expositions, teacher-centred methods.

All the IS teachers indicated that they teach following the IS syllabus topic chronology as is given. The IS teachers however, indicated that the time they spent on each topic varied depending on the available resources and the student characteristics. T74P revealed that he tries most of the time to rush through the syllabus so as to give more time for revision and preparation for examination.
4.3.4 Theme E: About school factors and student culture

A majority of the interviewees (six) opined that there was very little support offered to the IS teacher in the school system. The IS “teacher is left alone to find his way” as was articulated by T54P. This situation presented a lot of challenges especially to a teacher who has just joined the system whereby the “IS classes are too big and the school’s concern is on high student pass rates without consideration of the immense challenges faced by the teacher”, T52C. This stance was articulated by five teachers, two from Chemistry and all the three from Physics specialism (T54P, T61P, T74P, T52C & T31C). The challenges the IS teachers presented ranged from misprints in textbooks(T61P), lack of support for disabled pupils (T31C), Not enough time being allocated on the Timetable for IS teaching and learning (T52C). Seven IS teachers concurred on the lack of teaching and learning resources (T54P, T07B, T06B, T61P, T74P, T52C & T31C). T06B said, “IS is a practical science subject which should be taught through experimentation but in most of our schools there are no laboratories or reagents and chemicals. This negatively impacts in my teaching as I will be improvising and most times resorting to the easier route of theorising throughout the year.” T61P pointed out that, “Despite the large class sizes, there barely is any resources being bought by the school for teaching and learning. This is funny because such subjects like Physical Science with fewer students have resources bought for them almost each Term at my school”. Given such a scenario as presented by T06B it becomes understandable that maybe the low student achievement in IS might be partly attributed to the lack of teaching and learning resources in schools and the “resorting to the easier route of theorising throughout the year”.

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The IS teacher participants unanimously concurred that there was no regular review of IS curriculum at the school level. T07B revealed that, “The only modifications to IS teaching is left to the concerned IS teacher to draft a school syllabus which he or she puts in the departmental file”. On being probed further T07B emphasized that “this drafted school syllabus was not subjected to any interrogation by the department but was only a fulfilment of the ‘fixture’”. All the other participants also said that they either drafted an IS school syllabus or they just inherited what was in the file and sometimes without even reading it. T52C articulated this as; “with the high numbers of pupils to teacher ratio of 1 IS to an average of 52 students per class and one teaching 36 lessons of 40 minutes a week, there hardly is anytime for these things”. IS teachers in other words are overloaded with teaching in such a way that they barely have time to reflect on their teaching, what they tend doing is just “fulfilment of the fixture”, T07B. Although the IS is allocated six 40 minutes lesson periods per week in most schools the participants were teaching, 8 of the participants serve for 1 indicated that this time was not enough considering the demands of the IS syllabus and its broadness. T31C suggested that instead of allocating 6 lessons per week the lessons should be increased to 8 lessons per week so that there is enough time to go into the community as one teaches IS and facilitate the engagement of the students with the community and their environment.

On being asked on how the school community impact on the teaching of IS, most of the participants felt that the school and community influence was in a negative way as; “there is a tendency in schools to ‘streaming’ that is selecting the best students out of IS”, T74P. Within the school and the community, the participants felt that there was a propensity to thinking of IS as a soft science which therefore was often not being
granted primacy when allocating resources and to make matters worse the academically gifted students are often reserved for Biology and Physical Science subjects. The majority of the interviewed IS teachers felt that there was limited time to properly profile their students because principal of the students’ large numbers-high student to teacher ratio. One teacher from the Chemistry specialism said, “why should I concern myself with the student’s culture when there is a lot to worry about. I worry about lack of resources, high workload, students’ performance, low remuneration of teachers and such things”. Maybe this teacher T31C is not privy to the fact that profiling the students might assist in enabling him to work on improving their performance. The school factors which impact IS teaching and learning as raised by the participants are presented in Figure 23.

**Figure 28**

*About the school factors*
The structure of the IS subject which makes it a terminal subject at Form Four does not help matters. The students who have only done IS as a science, who by the way are the majority, do not have a direct way of continuing studying science post Form Four. The overloading of science teachers does not help matters. All the research participant proffered that as science teachers, if one did not hold an administrative role one was given the maximum teaching load of 36 hours per week. This prevailing situation is due to the shortage of science teachers in schools whereby the schools tend to take advantage of the available Human resources.

4.4 Summary

This chapter presented findings from the quantitative and qualitative phases of the research. Findings from the quantitative phase were organised into Biographical data analysis and results from section B of the questionnaire. Qualitative findings from the questionnaire and interviews were organised into themes. The themes which emerged from the qualitative data of the questionnaire are: Preparedness to teach IS, My IS teaching is derived from, Relevance of area of specialisation in the teaching of IS, Confidence in teaching IS, Challenges encountered in teaching IS, Most enjoyable when teaching IS, Instructional strategies used in teaching IS, Important scientific ideas which IS students should learn, Integrated Science Curriculum change, Reforming Teacher Education Curriculum change. On the other hand, qualitative data from the interviews resulted in the emergence of the following themes: About education background of the respondents, About teaching background, About IS student learning,
About IS teacher critical classroom experiences and About school factors & student culture.

Quantitative data collected via a questionnaire indicated that all the respondents were teaching IS at the time when the Instrument was applied. The respondents were deemed as experienced teachers with their experience ranging from 2 years to over 10 years of teaching experience. Questionnaire item 3 of section B was found to be significant at .05 alpha level on the Kruskal-Wallis test, and had statistically significant differences between groups of Integrated Science teachers. Integrated Science teachers who specialised in Chemistry education were much more likely to accept as true that teaching through practical work is as important as teaching theory in Integrated Science than those who specialised in Physics Education. The questionnaire item 1 was interrogating student culture and 7 was on teacher specialisation were considered to be just conditions. The just conditions were further interrogated in more detail during the interviews.

The qualitative findings found that teachers from the Physics cohort (60%) opinionated that their area of specialisation was irrelevant to teaching of IS compared to those from Biology specialism (10%) and Chemistry specialism (30%). Most of the participant identified their high school preparation as essential and a basis for their teaching of IS although those from Biology and Chemistry cohort also identified quite a number of courses from their college teacher education programmes. The majority of the interviewed teachers when teaching IS employed most times teacher centred methods. Most research participants indicated that they found no joy in teaching IS and went on to identify quite a number of challenges they encountered when conducting their
teaching business. These challenges ranged from lack of material resources like reagents and apparatus, heavy workload, content deficiency to general lack of support from the school administration and the community.

The next chapter, Chapter 5 will present a summary of the study, discussion of Findings, implications for practice and recommendations for further study. In this following chapter, the findings, as they relate to the theoretical framework of Teacher Knowledge, will be discussed and recommendations will be made as they relate to present and future studies of IS teachers and those teachers who find themselves teaching scientific concepts out-of-field of their specialisation.
CHAPTER 5
CONCLUSIONS AND IMPLICATIONS

5.0 Introduction

This chapter discusses the findings of this study as well as highlighting their implications for practice. The chapter also outlines recommendations for research and action to extend and enhance the teaching epistemic construction discussion for the research community and the teacher educators. This closing chapter has as intent to discuss the conclusions of this research study and relate these to present and future studies of IS teachers and those teachers who find themselves teaching scientific concepts out-of-field of their specialisation.

5.1 Discussions and Conclusions

The three cohorts of research participants of this study identified a common set of knowledge, skills, and dispositions that were, in their professional opinion, needed and in some instances, would enable them to teach IS. Questionnaire items 1 through 5, 8 through 11 and 15 of section B were directed to find answers for research question one. The free-responses from section C of the question during the 1st phase of the research were organised into the themes: preparedness to teach IS, my IS teaching is derived from, relevance of area of specialisation in the teaching of IS, confidence in teaching IS, challenges encountered in teaching IS, most enjoyable when teaching IS, instructional strategies used in teaching IS, important scientific ideas which IS students should learn, Integrated Science Curriculum change and reforming Teacher Education Curriculum change for the question. From the interview phase of the research emerged the following themes: about education background of the respondents, about teaching background, about IS student learning, about IS teacher critical classroom experiences and about school factors. These themes are merged during the discussion of the findings.
It was evident from the findings of this research that the research participants had considerable knowledge as well as clear views about what it meant for them to be teaching IS. Furthermore, the research participants also provided insights into the challenges they encounter as they implement the IS curriculum. Most of the research participants were deemed to be in a productive teaching age group as 57.4% of respondents reported their age group as being 39 or younger. The majority of the participating IS teachers were highly experienced with over ten years of teaching experience whilst the least experienced teachers were in the teaching experience range of two to four years. For the IS teachers who participated in the second qualitative phase of the research 67% held only a diploma in science education (Dip.Sci.). Of those in the Biology specialism only one teacher had only a diploma in education, two teachers from Chemistry specialism held a Dip.Sci. whilst all the three teachers from the Physics specialism held a Dip.Sci.. Three teachers had higher qualifications making up 33%, one from the Biology specialism was a holder of a bachelor in Science degree (BSc.Ed.), another one from the Chemistry specialism a certificate in education and BSc.Ed., whilst the third one from the Biology specialism had a Dip.Sci. and a Bachelor in Science Honours degree in Education (H.BSc.Ed.). This sample is a reflection of the situation in Zimbabwe whereby the majority of the teachers are diploma holders. The fact that all the research participants are trained teachers means that they are deemed capable of reflecting on their lived teaching experience vis-a-vis their teacher education curriculum they were subjected to. The research participants of phase 2 of the research were deemed sufficiently experienced with the least experienced being T06B and T52C with two years of post-qualification teaching experience, T07B and T54P had three years, T61P had four years, T13B had seven years, T31C and T74P had each ten years of experience, whilst the most experienced teacher being T48C with thirteen years.
Research Questions 1

*How do teachers who specialised in Chemistry, Biology or Physics describe secondary school Integrated Science teaching?*

Little is known about Teacher Knowledge among IS teachers who specialised in specific science discipline like Chemistry, Biology or Physics, in particular, how their knowledge, goals and images, school environment, student culture and available resources combine to produce their actions and decision-making in an IS classroom. Analyses of quantitative and qualitative data collected from an initial 60 and a selection of 9 of the 60 respondents via a survey in phase 1 and interviews in phase 2 respectively painted a picture of what teachers knew and understood about their IS teaching.

**Practical work when teaching IS**

The IS teachers’ responses to 14 section B questionnaire items generally showed no significant differences among the three IS teacher cohort scores at .05 alpha level. The responses to the questionnaire items 1, 2 and 4–15 were not statistically significant. In other words, there was no marked difference in views across the three cohorts on these questionnaire items. However, the teachers’ views across the cohorts on questionnaire item 3 were statistical significant, and also to some extent items 1 and 7 showed marginal significance at $p = 0.051$ and 0.084, respectively and hence considered as just conditions.

Questionnaire item number 3 read, “Teaching through practical work is as important as teaching theory in IS”. Upon analysis of the questionnaire item number 3 response it was found that Integrated Science teachers who specialised in Chemistry education were much more likely to accept as true that teaching through practical work is as important as teaching theory in Integrated Science than those who specialised in Physics Education. Whilst about 88% of the respondents agreed to item 3’s assertion, about 12% disagreed to this. The IS syllabus
document however demands, “practical and investigative approach must be adopted in teaching this syllabus” (ZIMSEC, 2010, p. 2). Despite the IS teachers resonating with the importance of practical work in teaching IS and being aware of the demands of the IS syllabus document, they however, indicated that there were massive challenges encountered when embarking to teach through practical and these dissuaded them from engaging their students in Practical work and they resort to teacher centred methods of teaching especially those from the Physics cohort.

The challenges cited as impeding engagement in practical work ranged from lack of reagents, apparatus to absence of laboratory space. This lack of reagents and apparatus was exacerbated in most of the schools where the participants were working by a very ‘high student to teacher ratio’. Some teachers in the Chemistry and Physics cohorts also said that the IS syllabus was too broad such that time allocated for covering this syllabus was too little such that if a teacher resorts to teaching through Practical work the syllabus will not be finished in time for the students’ final examinations. According to the participating IS teachers these challenges had a push factor for them to resort to teacher-centric teaching approaches.

The chemistry education cohort were found to be more strongly aligned to practical work teaching approach than the other two cohorts. For the Physics cohort, theorising more when teaching IS was more convenient than engaging in Practical Work. This sentinel position of teachers from the Physics specialism is in line with the findings of Hashweh (1987) and Nixon & Luft (2015) that if teachers’ Content Knowledge is low, it directly influences the way they teach, often times they find themselves comfortable with sticking to the script, employing more teacher centred approaches and the resultant is the accompanied reduced teaching effectiveness as a result of limited content knowledge (Hobbs, 2013). It should be noted that this study is however, not implying that holding a degree qualification with requisite Content Knowledge
makes teachers proficient, but, holding a teaching qualification in the “content area serves as a readily available minimum requirement” (Nixon & Luft, 2015, p. 76). Topic-knowledgeable teachers are often-times more likely to diverge from textbook accounts and demand synthesis from their students and engage in practical activities (Hashweh, 1987). The teachers from the Physics education cohort seem to be less exposed to biology concepts and to some extent chemistry concepts and these are the major concepts which make-up the Integrated Science curriculum at Ordinary Level in Zimbabwe (ZIMSEC, 2010).

Although the IS teachers in the three cohorts assert that teaching through Practical Work is enjoyable, this, however, contradicts with the teachers’ earlier assertion that they do not carry out Practical Work because of multiplicity of challenges which encompass the lack of reagents and apparatus. Maybe the teachers were referring to the sparse occasions in which they were able to undertake some Practical Work. Despite citing the inadequacy of resources for carrying out Practical work, some IS teachers indicated Practical Work was the most used and preferred teaching strategy if teaching conditions are right. Below half of the participants engage in practical activities despite the Integrated Science syllabus guidelines putting an emphasis for teachers to provide pupils with practical and investigative experience. A sizeable number of teachers across the 3 cohorts use lecture method despite the syllabus’ guidance to use child centred instructional strategies. Roth (1987) upon studying of junior high life science teachers demonstrated that espoused Teacher Knowledge is a necessary but not sufficient condition for successful conceptual change to teaching. Carlsen (1988) also noted that often times teachers are aware of the importance and the demand to engage their students in ‘Practical Work’ but they however, may decide not to engaging their student in such activities. The identification of Practical Work particularly as challenging resonate with a study carried by Childs & McNicholl (2007, p. 10) who found out that teachers teaching out-of-field of specialisation felt “anxieties
about the pitfalls of particular Practical activities: how to deal with any unexpected developments, how to ‘fix’ them and indeed if things went wrong how to explain the unexpected to students”. However, in this study challenges around the carrying-out of Practical Work were attributed primarily to inadequacy of resources.

The IS teachers especial from the Biology cohort however acknowledge the importance and relevance of Practical Work through experiments, field visits, observations, practical activities and tests as crucial strategies which facilitate learning of IS. The teachers however indicated that the school situation is such that there are limited resources, there is not enough time allocated on the time-table to conduct these practical activities and also that some of the teachers need to be trained to conduct some experiments which lie outside his area of specialism. This finding however contrast that of Kind (2009) who found whilst researching on prospective teachers that if they are teaching out-of-field lessons they prepared more intentionally than for their in-field lessons, drawing on a wider variety of resources, consulting colleagues, and practising demonstrations in advance and hence such teachers deliver better lessons without undergoing formally training. This might be so in situations where there is abundance of other trained teacher to consult but in the case of the Zimbabwean situation very few schools have more than one trained science teacher. On further interrogating the physics cohort on teaching approaches used and the role of practical work in teaching IS, they expressed that learning of IS in their classrooms is facilitated through studying of primary textbooks, information from industries, television programs and seminars as well as at instances some experimentation using available resources facilitate student learning. The IS teachers from the Physics cohort were however frustrated that were not conducting experiments such as the series of experiments on photosynthesis in the Science in Agriculture section. These series of experiments lie outside-of-field of specialisation. It might seem as if those practical activities
which are outside a teacher’s field-of-specialisation present problems when it comes for the need to improvise. The fundamental role of curriculum materials for instructional design has also been outlined by Beyer, Delgado, Davis, & Krajcik (2009) who illucidated that those teachers teaching outside their content area tend to extensively rely on such materials. The importance educative curriculum materials as fundamental to teacher learning have been echoed in a number of researches (Davis & Krajcik, 2005; Collopy, 2003; Schneider & Krajcik, 2002). It then becomes problematic if these teachers especially those teaching out-of-field of specialisation are not exposed to the essential educative curriculum materials like most of the research participants. All the interviewed teachers from the Physics cohort placed emphasis on teacher centred approaches when teaching IS citing a number of reasons which included lack of resource to embark on the practical and investigative approach.

The IS teachers in the chemistry cohort also indicated that the schools they were teaching had a deficit of scientific instruments and chemicals, had large classes making lesson delivery and students contact poor and so they did not embark on practical work and hence most experiments were not done. Some of the teachers from this cohort however indicated that they improvised when teaching Science in Structures section of IS syllabus. It might therefore be pointing to a situation whereby when teaching in-field of specialisation, IS teachers are at liberty to improvise.

In the spirit of Integrated Science teaching methodologies, resources, yes, are key but the major resource is the community in which the school is located such that experiments like, for example those to do with conditions necessary for phosynthesis can be carried out using the local available plants. What might be the issue here is not only the scarcity of reagents and apparatus but fundamental the Content and PCK gap of most of these participating IS teachers.
Influence of students’ cultural background on learning IS

Knowledge about students’ cultural background and its influence on students’ misconception on certain scientific concepts together with the ability of a teacher to manage these misconceptions lie at the heart of what effective science teachers do and are indeed important aspects of PCK (Shulman, 1986, 1987). The research participants were generally in concurrence across the cohorts that students’ culture was essential for learning IS, this disclosure is consistent with the research findings of Dziva, Mpofu, & Kusure (2011) although the research participants in the Dziva, et.al (2011) study placed the students’ cultural knowledge on a low rung of importance.

Although the majority of teachers from the Chemistry cohort were persuaded that student culture was an important factor when teaching IS, some teachers from the Chemistry specialism felt that students’ culture was the least of their worries as they had to grapple with lack of resources, high workload, students’ performance, low remuneration of teachers and such things. These teachers might not be privy to the fact that profiling the students culture might assist them in working on improving their performance. Most teachers from the Physics cohort were also of the idea that culture was immaterial when teaching IS as there were other pertinent to contend with like lack of motivation of the learners and shortage of teaching and learning resources.

Content Knowledge challenges when teaching IS

Some Chemistry and Physics IS cohort teachers felt that the teachers’ content knowledge was presenting challenges. This finding resonates with the observation which had been made that when teachers find themselves out-of-field, in most cases this out-of-field situation comes
along with considerable knowledge gaps in Content Knowledge and PCK (Schueler, Roesken-Winter, Jochen, Lambert, & Matthias, 2015). Research shows a positive nexus between teachers’ preparation in their subject matter and how they perform and impact in the classroom (Wilson, Floden, & Ferrini-Mundy, 2001). Teaching of such topics as Science in Agriculture, Science in the community presented challenges for some teachers from the Chemistry cohort such that they had to rely on Ordinary Level knowledge which they learnt years back in order to teach these topics. A majority of IS teachers who specialised in Chemistry Education and Biology Education held the view that it was not important to specialise in a single science discipline. For those who specialised in Physics education only 25% of IS teachers reported as agreeing to the potential of being better teachers if they had not specialised in only Physics Education.

IS teachers from the Chemistry and Biology cohorts viewed the content they learnt as having immense import when they teach IS. On the other hand, those from the Physics cohort emphasized on the ability to manage the teaching and learning process, and also being skilful and innovative when delivering the IS lessons due to the knowledge they received from college. This seems to resonate with the fact that there are a limited number of Physics content concepts in the IS curriculum and therefore the IS teachers in the Physics education cohort resort to mostly professional courses they received whilst undergoing teacher preparation, for teaching IS.

Quite a number of teachers from the Physics and Chemistry cohorts opined that the broadness of the IS syllabus made the teachers rush over as they teach in order to finish teaching in the prescribed time and hence sacrificing student learning. Maybe the way in which these IS teachers teach leads towards the time being insufficient. If these teachers lack the resources to teach IS, it might mean that their approach is teacher centred which then put a burden upon
them “for completion of the syllabus” and hence time becomes limiting. Despite having indicated that IS syllabus is rather too long for the two years in which it should be learnt, some IS teachers mostly from Biology specialism cohort still suggested that there is need to add some concept which they felt were an important aspect of student learning. However, those teachers in the Chemistry specialism cohort and some in the Physics specialism cohort felt that there was need to reorganise the whole Ordinary Level curriculum in such a way that some IS content are moved to other school subjects such as Agriculture and Geography. This might be an indication of the underlining unpreparedness of these teachers to teach the content they had not learnt at college. Some teachers during the interviews felt that instead of allocating 6 lessons per week the lessons should be increased to 8 lessons per week so that there is enough time to go into the community as one teaches IS and facilitate the engagement of the students with the community and their environment. Some teachers who specialised in Biology identified the Physics and Chemistry sections of IS syllabus as presenting some challenges, whilst some of those who specialised in Chemistry identified Science in Agriculture and the teaching of concept on motors and generators as challenging. Those who specialised in Physics deemed the Biology and Chemistry section of the syllabus as challenging. The discomfort of the research participants in out-of-field teaching is demonstrated here as the teachers identify those concepts which lie outside their areas of specialisation as challenging. The teachers’ articulations of these challenges are in line with conceptualisation of Teacher knowledge and Pedagogical Teacher Knowledge in that for a teacher to be competent there should be mastery of Content and pedagogical knowledge which Shulman (1987) articulated as an amalgam of content and pedagogy.

Most IS interviewed teachers perceived that they did not find any bliss when teaching IS. This lack of enjoyment was attributed by the Physics cohort to the shallowness of IS content-wise
and by the Biology and Chemistry cohorts to “little support” offered by the school. This lack of support is said to be manifesting itself through lack of teaching and learning resources. Some teachers from the Chemistry cohort blamed the lack of enjoyment on IS pupils who have a negative attitude towards the subject because the subject does not prepare them for Advanced Level studies. A majority of IS teachers from the Biology specialism however, perceived that they derived joy in teaching IS. Maybe this is due to the fact that most IS content is basically biological in nature.

IS teachers in the 3 specialisation cohorts suggested mostly as important concepts to be learnt in IS those in their area of specialisation e.g. those who specialised in Chemistry education suggested mostly Chemistry concepts serve. The Physics education specialisation cohort indicated in addition that some chemistry concept were also important concepts. It seems that although these teachers are teaching Integrated Science, their area of specialisation remains a major influence in the decision they make in the classroom, what they deem as important in student learning is based on their area of specialisation. Engagement in practical work was however, raised as a key classroom experience by most participants in all the 3 cohorts despite them not facilitating the learning of IS through Practical work.

Preparing to teach IS

When preparing for IS lessons, a substantial number of IS teachers said that they had to consulted textbooks. Some IS teachers said that they relied on the internet as a source when preparing to teach IS. It is worth noting that not even a single teacher who specialised in Chemistry save for one indicated any form of research as they prepare to teach IS. Integrated Science teachers’ top sources for teaching were identified as textbooks, internet searches, their secondary school experience, college preparation and life experiences. Of the IS teachers who
indicated experience as essential for preparation to be a better IS teacher 56% were those who had specialised in Physics, 28% being those who had specialised in Chemistry whilst only 17% were those who had specialised in Biology education. These figures might be indicative to the fact that maybe those who specialised in Biology feel better equipped for teaching IS upon graduation whilst at the far end those who specialised in Physics need some more years of experience, learning in the field to be better teachers of IS.

**Confidence when teaching IS**

The majority of IS teachers across the three cohorts indicated that they were confident in teaching IS. Confidence to teach might be interpreted as not being nervous when delivering IS lessons. Since all these IS teachers are deemed as experienced, they might be able to put a brave face even when teaching those concepts which they have no firm Pedagogical nor Content Knowledges. These teachers might have developed the ‘tricks of the trade’ whereby they are confident in the face of uncertainty.

**Learner characteristics constraints**

The cohort of teachers who specialised in Physics identified most challenges which they attribute to learner characteristics whilst only one teacher per Biology and Chemistry cohorts perceive that learners’ background or prior knowledge of science was poor and hence the learners would not have been prepared enough to tackle Integrated Science at Ordinary Level. The Physics specialisation cohort perceived that the learner characteristics presenting challenges was that IS learners were slow learners and hence they failed to for example “draw complex diagrams”, “find it difficult to understand the concepts” and they “fail in the final examinations”. It is interesting how the teachers from the Physics cohort point a finger on learners’ weaknesses without also acknowledging that they also have a shaky background
formation for teaching some IS concepts. IS teachers alleged that learners’ lack of motivation presents challenges as they implement the IS curriculum. It is however, enlightening that these teachers recognise the learner characteristics as an important factor in student achievement but what might be lacking on their part is how they should be dealing with these ‘learner deficiencies’ so as to improve student achievement instead of just ‘blaming’ their students.

**Resource constraints**

Quite a sizeable number of IS teachers have coined resource constraints as a fundamental impediment in implementing the IS curriculum. Teaching and learning resources constraint in the developing countries like Zimbabwe are a major reality in the education sector, however, the IS teachers should be able to improvise and make the best of the available resources as highlighted by some teachers from the Biology and Chemistry cohorts.

**Classroom management**

Student management is another challenge encountered by some IS teachers. Managing a large class of students as a challenge recurs in all the three groups of teachers, with groups ranging between 50 to 63 students per class per teacher being cited by the research participants. This high student to teacher ratio on the backdrop of limited reagents, apparatus and laboratory space put a lot of pressure on IS teachers. It seems as if these teachers are failing to manage teaching of large classes and therefore resort to “theorising experiments”.

**Suggestions for teacher education and IS curriculum reformation**

On suggesting reforms to teacher education curriculum, IS teachers raised indications on the need to integrate e-learning, put more emphasis on Practical work, revise the teaching methodologies taught and avoid specialism when preparing teachers for IS teaching. The need
to learn through Practical work was sighted as paramount in changing teacher education curriculum together with integration of e-learning. IS teachers from the Biology specialism were promulgating for minor reforms in IS curriculum, specifically related to the better implementation of the curriculum that is teaching through Practical work and aligning the IS content to the immediate student environment. IS teachers holding Chemistry specialism were general of the opinion that the IS curriculum is too long and should be trimmed. IS teachers holding a physics specialism seem to be of the view that a change in IS curriculum should be inclined towards industrialisation and basic science studies.

Research Question 2

*What are the gaps in knowledge between the Integrated Science teachers’ espoused knowledge from teacher education institutions and the enacted experiential knowledge needed in Integrated Science classrooms?*

Several gaps emerged on the knowledge of IS teachers as they articulated their espoused knowledge from tertiary institutions against their enacted experiential knowledge needed in IS classrooms. Most of this knowledge came out as challenges the teachers encountered as they endeavoured to implement the IS curriculum.

**IS teaching formation/roots**

The teachers who specialised in Biology education indicated a number of courses which they took at college aid them in the teaching of IS. Biology and High School Advanced Level courses are indicated as essential background which enable them to better teach IS, whilst a few teachers from this cohort associate better preparation for teaching IS with learning Philosophy, Psychology, Sociology, Pedagogics, Curriculum Studies, Educational technology, Microbiology, Biological techniques or Theory of education in general, Plant physiology, History of Science and Professional Studies courses. The teachers from the Chemistry cohort
recognised subjects taken at secondary school level as essential preparation for teaching Integrated Science. They alleged that these subjects formed the bedrock of IS teaching. The Chemistry cohort also identified High school/Advanced Level sciences, Chemistry area of specialisation and Practice teaching, Micro-techniques, Mathematics, Media technology, Philosophy, Curriculum studies, Psychology or First year courses as essential in pre-service teacher for IS teaching. The majority of the teachers who specialised in physics identified professional courses as essential for preparing to teach Integrated Science. Physics, AVA (Audio Visual Aids), Family, Health and Life studies, Applied Heat and Management, Applied Mechanics, Electricity and magnetism. Of note is the identification of secondary and high school science subjects and professional courses by all the three interviewed IS teachers from the Physics cohort as being an essential foundation for teaching IS. It is interesting to note that despite these teachers having been taught a substantial amount of content courses in their area of specialisation they only perceive a few content courses as essential for the teaching of IS serve for those who specialised in Biology who indicated five courses from their area of specialisation. Overall, professional studies courses were cited by IS teachers across the cohorts as impacting positively in their teaching of IS. This finding might be implying that the majority of the courses taken by these teachers have no direct bearing on the teachers’ professional practice considering the fact that all secondary schools in Zimbabwe offer IS and a limited number of these schools and students take Physics, Chemistry or Biology as stand-alone subjects.

Gaps between espoused and enacted knowledge depicted through challenges encountered by IS teachers

The research participants pointed to copious challenges which impede them from effectively conducting their lessons. Nixon & Luft (2015, p. 77) point out that although the effect of out-of-field teaching has been researched ‘there is limited research on how teachers negotiate the
challenges of out-of-field teaching”. Nixon & Luft (2015) goes on to identify the only exceptional studies as those conducted by Childs & McNicholl (2007) and Sanders, et.al. (1993). In order to alleviate the challenges encountered when implementing the IS curriculum, the research participants raised indications on the need to adjust teacher education curriculum through incorporating a robust e-learning regime, teaching most concepts in teacher education programmes through Practical work, revising the teaching methodology course so that they are in-line with methodologies required for IS teaching, avoiding specialism when educating IS teachers and improvement in supply of resources needed to engage students in Practical Work and investigative approach. The need to learn through Practical Work was sighted as paramount in changing teacher education curriculum together with integration of e-learning. Student engagement in Practical Work was raised as a key classroom experience by the participants. The IS teacher further suggested varied modifications to the content courses to be offered in a modified IS teacher education programme. These modifications were specialisation cohort dependant such that teachers who belong to for example the Physics cohort would suggest removal of say major sections of Science in Agriculture and suggesting that these be incorporated into the school subject Agriculture. What the teachers might be missing is that Agriculture as a subject is not done by all students in Zimbabwe and the suggestion made might have been concerted way of trying to get rid of those concepts which are out of field for them.

The findings of this study unveil knowledge that seems to fall into the space made up of knowledge that is part of intended student learning as depicted in the syllabus document, of which knowledge the IS teachers are aware of, but of which the students are not exposed to due primarily to school situation in which the resources (chemicals, reagents, laboratory space and human resources) are lacking. Besides the fact that teachers of IS are aware that teaching through practical work and investigative approach is required and essential for IS teaching,
these teachers mostly from the Physics cohort do not follow this approach of teaching. Assuming that teaching well is a result of teachers being aware of the available pedagogical options; this study however indicate that the school situation plays a significant role on how the knowledge demanded of a teacher plays out in practice. For those teachers who find themselves teaching concepts out-of-field of specialisation like is the case for the physics cohort the outplay of the demanded Teacher Knowledge goes well-beyond simply knowing the syllabus rules and how to manipulate them with fluency. The out-of-field of specialisation teachers find comfort in engaging in teacher centred methods of teaching, whereby they resort to theorising. On being asked on which resources they mostly rely on when delivering IS lessons during the interview sessions, about 78% of the IS teachers indicated their over reliance on chart diagrams. This probable is pointing to the fact that a majority of the participants have a tendency of bordering their lesson delivery around teacher-centric methods. It is most likely that these IS teachers suffer from deficiencies in PCK for those concepts which are out-of-field of specialisation and also this might be a symptom of shortage of resources for Practical work. This study provides contextual inputs to effective IS teacher education re-alignment informed by the IS teacher practitioners, those with the craft knowledge of the contextual environment of the Zimbabwean IS classrooms. Ultimately, with the findings of this study a tool for recruiting and developing teacher educators who can effectively teach IS can be developed.

The results of the study indicate that the IS teachers’ knowledge was not directly related to years of IS teaching experience (i.e., 2 to 10 years of experience). No evidence for any occurrence of a phenomenon which might be referred to as ‘experience related teacher knowledge correspondence’ where there is coalescence of knowledge among the 3 IS teacher cohorts such that as IS teachers become more experienced they gradually shift away from the influence of their area of specialisation was encountered. It was not found, for example, that
T#B and T#P teachers’ views coalesced with more years of experience. The IS teachers in T#P cohort can be described, in a general way, as teachers who are more focused on the teaching of Content Knowledge/subject matter and worry a lot about resource shortages. The teachers in T#B can be described as focused on teaching of Content Knowledge/subject matter, students’ knowledge, understanding and personal development, as well as on preparing them for the future. Whilst those from the T#C cohort may be described as focused on students’ knowledge and understanding and personal development and on teaching of content knowledge/subject matter.

5.2 Implications of the study

Lack of successful implementation of many curriculum innovations is often attributed to the failure of teachers to implement the curriculum in a way corresponding to the intentions of the curriculum developers, the school system and the generality of the populace. Without glimpsing on the knowledge base of the teachers who are implementing a curriculum, any curriculum implementation process will suffer a stroke and without cardiac massage efforts it will naturally die off. It is therefore prudent to study whether teachers adapt their teaching practice, that is, change their classroom behaviour and beliefs once deployed into school systems. Often times teachers are blamed for relative lack of success of a curriculum without the researchers, teacher educators and curriculum developers having taken into account the teachers’ knowledge and how it has been influenced by the students, teachers’ beliefs, school culture and the available resources among other things.

The sensitive and delicate process of Teacher knowledge research and networking and reflection opportunities

As the IS teachers were revealing their knowledge especial during the interviews, they became exposed and instead of pursuing a description of a better understanding of IS teaching through
merely articulating the Teacher Knowledge they have, they were often times found in the act of being uncertain. The participating IS teachers continuously needed to be supported and nurtured during the interview phase as the research process became a very sensitive process, so that they would feel at liberty to express themselves and become empowered. A research implication in this respect could be the need for researchers to create an ambient where teachers feel self-confident enough to explore their Teacher Knowledge with others.

During the interviews and their analyses, it became apparent that when the teachers disclose their teaching experiences, the process of disclosure enabled them comprehend and better articulate their knowledge. Teacher educators should provide opportunities for self-reflection and collaboration of student teachers whilst they are on teaching practice so as to enable them interrogate their understanding of their teaching and their selves in a neutral and non-threatening environment through, for example, termly special seminars where they congregate and share their experiences and/or through social media chat groups like WhatsApp, Facebook or Twitter. As well such opportunities should be availed to practising teachers.

**Implication for teacher education: Teachers participation in knowledge creation**

As teachers are regarded as sources of knowledge in research, they should also be regarded as sources of knowledge in their classrooms. Teacher Knowledge should therefore be considered as that which teachers create within their existential circumstances. This knowledge should therefore be a key base for the teacher education curriculum. Teacher-educators and researchers should be careful when contesting the enacted knowledge of teachers which comes into being as a result of the intermingling of educational theories, subject matter knowledge, teaching environment, their beliefs, and the subjective interpretations of classroom processes (Breen, 1991) and the gaps between these knowledge types. Researcher or teacher educators upon
reforming teacher education programmes should not be the sole knowledge experts, it is important to comprehend and build together with the teacher different knowledge sources relevant to the diverse classroom situations and desist form challenging educators. During such process teacher educators can assist student and practising teachers to acknowledge and reflect upon their personal beliefs on content areas they are going to teach or are teaching.

**Recommendation for Further Research**

Shulman (1987)’s ideas on multiple categories of Teacher Knowledge have been refined and developed by other researchers into distinct models of Teacher Knowledge. Few studies however use most of Shulman’s seven categories of Teacher Knowledge as analytical framework (Corrigan, Dillon, & Gunstone, 2011). Most studies have taken mostly Pedagogical Content Knowledge as an analytic framework (Grossman, 1990; Verloop, Driel, & Meijer, 2001; Gess-Newsome, 1999). Shulman (1987) emphasized the interrelatedness of the seven forms of teacher knowledge, so for any analysis of teacher all of these forms of teacher knowledge should be studied as they are bound together and empirical researches exploring the interlink of these knowledge types might help in exposing this complex concept, Teacher Knowledge. Therefore, further researches that analyse all the 7 forms needs to be conducted to understand how all the forms of Teacher Knowledge relate to each other and are developed in science teachers who teach science concepts outside-their-specialism.

Further research in Teacher Knowledge of preservice science teachers in Zimbabwe and elsewhere on student science teachers embarking on teaching practice might document how their Teacher Knowledge develops as they teach some science concepts which lie outside their area of specialisation. It would be informative to monitor how these student teachers develop their Teacher Knowledge and whether there are any differences between how their teacher
knowledge develops during this period and when they have gained years of field experience. Student performance is also another area which might warrant further research. How do students perform when taught a particular concept by out-of-field science teachers? This performance could be measured immediately after the lesson has been imparted and then follow-up studies made on retention of this imparted knowledge.
References


Handcock, M. S., & Gile, K. J. (2011, August 2). On the Concept of Snowball Sampling.


http://www.zimsec.co.zw/an-analysis-of-the-november-2016-ordinary-level-examination-results/


Appendix A: The Basic Secondary School Science Teacher Knowledge Questionnaire

Dear participant:
This questionnaire intends to solicit your views on the various aspects of your teacher education and work as an Integrated Science teacher. It is part of a research project I am carrying out to understand what constitutes the various areas of basic Integrated Science Teacher Knowledge, how it is drawn upon in university/college curriculum and in practice, what shapes it and what factors are related to the actualisation of teacher knowledge. Your cooperation is greatly appreciated.

Instructions: Please place a tick (✓) where appropriate or write on the corresponding space provided.

Section A: Demographic Data

a. **Gender:** Male ( ) Female ( )
b. **Age:** 20-24 ( ) 25-29 ( ) 30-34 ( ) 35-39 ( ) 40-44 ( ) 45 or more ( )
c. **Qualification(s):** .................................................................
d. **Name School at which you are teaching:** ......................................
e. 

**Subjects you are currently teaching**

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**Teaching experience in years:** Less than 1 ( ) 2 to 4 ( ) 5 to 9 ( ) 10 or more ( )

Section B: Science teacher knowledge

Please read the statement carefully and put a tick under the response which best correspond to your point of view.
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<thead>
<tr>
<th>Statement</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree nor disagree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
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<tbody>
<tr>
<td>1  Teaching Integrated Science (IS) requires knowledge of students’ culture.</td>
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<td>2  It is important for IS teachers to know the history of science.</td>
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<td>3  Teaching through practical work is as important as teaching theory in IS.</td>
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<td>4  I frequently use practicals to enhance students’ learning of IS.</td>
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<td>5  Teaching of IS is different from teaching other science subjects.</td>
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<td>6  Specialising in a particular science discipline at college is important in the teaching of IS</td>
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<td>7  I could be a better teacher of IS if I had not specialised in one science discipline at college.</td>
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<td>8  When teaching a particular section of IS a teacher should divert and teach another aspect of IS if that aspect captures students interest at that time.</td>
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<td>9  The rate of student learning does not impact my teaching of IS.</td>
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<td>10 Using audio and visual aids is important in facilitating students’ learning of IS.</td>
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<td>11 Integrated Science teaching should mostly be done outdoors</td>
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<td>12 I am not well trained in the use of aids when teaching IS.</td>
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<td>13 The subject matter/content taught at college/university is enough for one to teach IS.</td>
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<td>14 Upon being employed I had to start reading hard in order to be able to teach those topics in IS divorced from my area of specialisation.</td>
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<td>15 Integrated science teaching should mostly be conducted in-doors i.e. in laboratories or classrooms.</td>
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Section C: (open-ended questions)

Please write your response on the space provided below each question.

a) Is there a need for a change of the science teacher education curriculum? If so, what aspects of the science teacher education curriculum do you feel need to be revamped in order for one to effectively teach Integrated Science? If not, why should it be maintained as such?

b) Where do you derive the knowledge that shapes your teaching of Integrated Science?

c) Describe the relationship between the preparation to teach you received at university/college and the teacher knowledge required for teaching IS in practice?
d) Based on what you know as a classroom teacher:

i. What are some of the important scientific ideas the IS students should learn at ordinary level?

ii. Are these ideas in (iv) a) taught to student teachers at college?

iii. What instructional/teaching strategies and/or tasks do you normal use in teaching IS? Why?
e) What challenges do you encounter when teaching IS?

f) From the courses you pursued at college which ones do you think enable you to better teach Integrated Science?
   i. What is most enjoyable when teaching Integrated Science?
   ii. What is most difficult about teaching IS?
g) How confident do you feel about instructing students in different Integrated Science topics?

h) You specialised in a particular science discipline at college/university. Which one? Does your area of specialisation aid or not your teaching of Integrated Science?

Dear participant,

I may need to scan copies of your integrated science teaching documents in another stage of this project. There is no compulsion for you to participate and you may at any stage withdraw your participation. Any information which you give will be used solely for the purposes of this research project, and all information you give will be treated as confidential. If you choose to
be included, you will be asked to provide your Integrated Science teaching documents. These documents might include schemes of work, lesson plans, hand-outs, and/or a sample of marked students’ works.

CONFIDENTIAL
All collected artefacts, data, and information will be kept confidential and secure to ensure privacy for each and every participant. Information used in the final report (thesis or an academic paper) will not have real names of participants but pseudonyms will be assigned. Your involvement in the study is voluntary and you may withdraw from the study at any time and/or withdraw any data that you have provided to that point.

If you wish your Integrated Science teaching documents to be duplicated, please give me your contact details below.

Name:.................................................................

Telephone number:..............................................

Email:..............................................................................

Thank you for your cooperation and interest in the study.
Appendix B Integrated Science teachers standard interview guide questions

A) About education background of the respondent
- Can you tell me about your education background? Which Science subjects did you take at Ordinary and A-Levels?
- Does your educational background assist in your teaching of IS? In what ways? /Why is it/not of any assistance in teaching IS?

B). About teaching background
- How long have you been teaching IS?
- Do you have any special expertise which facilitate your teaching of IS?
- Do you feel your college education is adequate preparation for teaching IS? Why?
- Which areas of IS do you deem lie outside your specialism?

C). About IS student learning:
- How do you think students at forms 3 and 4 learn IS?
- What do you do as a teacher that helps that learning of IS to occur?
- What kinds of things do you think forms 3 and 4 IS students need to learn?
- Is there a school-wide assessment regime? How does it work for IS?

D). About IS teacher critical classroom experiences:
- Do you enjoy teaching IS science? Why/why not?
- What do you think students need to learn about science at Ordinary level?
- Any thoughts about how students learn these kinds of things?
- What do you see as your role in IS learning at this level?
- What is the role of practical work in IS teaching?
- How else do you promote IS learning?
- Do you teach IS topics as per syllabus topic/unit chronology? If not, why?
- Is there anything else you want to tell me?

E). About school factors and student culture
- What are the school expectations for IS? (long term plans, policy, resource mobilisation etc)
- Is there a programme for regular school review and how does it happen for IS? Does this impact on the way IS is implemented in the school?
- What support is there for IS? E.g. such things as planning support/resources accessibility of equipment/timetabling/budget/professional collegial support.
- Are there any aspects about this school or community in general that influence what you do in IS lessons? Are there any parental views or issues that you think affect IS delivery in any way?
- Does student culture play any role when teaching IS? How?
Appendix C: Permission to carry out research

Reference: C/426/3 Harare Province

Ministry of Primary and Secondary Education
P.O Box CY 121
Causeway
Harare
10 October 2015

Diamond Dziva
BINDURA

RE: PERMISSION TO CARRY OUT RESEARCH AT ____________YA,

Reference is made to your application to carry out a research at the mentioned schools in Harare Metropolitan Province on the research title:

"THE CONCEPT OF BASIC SECONDARY SCHOOL SCIENCE TEACHER KNOWLEDGE: REFORMING SCIENCE TEACHER EDUCATION IN ZIMBABWE"

Permission is hereby granted. However, you are required to liaise with the Provincial Education Directors Midlands, Mashonaland Central and Harare Metropolitan Province, who is responsible for the Province you want to carry out your research.

You are required to provide a copy of your final report to the Secretary for Primary and Secondary Education by December 2015.

E. Chinyowa
ACTING DIRECTOR: Policy Planning, Research and Development
For: SECRETARY FOR PRIMARY AND SECONDARY EDUCATION

cc: P.E.Ds. Harare Metropolitan
    P.E.D. Midlands
    P.E.D. Mashonaland Province
Patras, 24. 9. 2014

Dear sir/madam,

Daimond Dziva is a PhD student in the Department of Educational Sciences and Early Childhood of the University of Patras in Greece. His research area is science teacher knowledge and as part of his studies he should collect data from teacher training institutions as well as novice and experienced Integrated Science teachers in Zimbabwe. We would like to request that you assist him within your possibilities in his endeavour.

Thank you in anticipation of your assistance.

Best regards,

Konstantinos Ravanis