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THE RELATIONSHIP BETWEEN NOVICE PHYSICAL SCIENCES TEACHERS' BELIEFS AND GOALS TO INQUIRY-BASED INSTRUCTION

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DECLARATION

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DEDICATION

This dissertation is dedicated to my family. Thank you for your love, encouragement, and support while completing this degree. You are the best.

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I am ready for anything and equal to anything through Christ, Who infuses inner strength into me.

Philippians 4:13 (Amplified Bible Classic Edition)

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ABSTRACT

Inquiry-Based Instruction (IBI) has been positively associated with quality science education for the past 50 years. Research studies in science education cite beliefs and goals as the main reasons for the lack of IBI in science classrooms. Nevertheless, previous attempts to understand the reasons for this lack of IBI revealed a mismatch between science teachers' beliefs to classroom practices. The research gap on improving physical sciences teachers' IBI practices persists despite studies on teachers' beliefs to classroom practices. This gap in the literature and continued use of traditional instruction have motivated this study to ascertain the impact of beliefs and goals in classroom practices. Framed by the constructivist learning theory and goal-driven teacher cognition model, this study explored the relationship between novice physical sciences teachers' beliefs and goals to IBI practices. From a goal-driven theory of cognition perspective, teachers' actions are an attempt to satisfy one or more of the goals they hold.

This multiple qualitative case study was couched within the constructivist research paradigm. Four novice physical sciences teachers were purposively selected to participate in the study. Data were collected through multiple sources, including three open-ended questionnaires (TBI, POSTT, TGI), classroom observations, stimulated-recall interviews, collected artefacts, and field notes. The findings of this study revealed that despite the curriculum advocating IBI, novice physical sciences teachers' enactment is at a low level, teacher-centred in their classrooms. Findings suggest that IBI practice is facilitated by mediating teaching and learning beliefs with environmental factors for goal adoption. They further provide evidence suggesting that the goals teachers pursue are influenced by their teaching and learning beliefs and their schools' environmental factors. Among the key lessons from this study is that it is essential to help physical sciences teachers develop and pursue beliefs and goals that characterise IBI practices that have the potential to improve science education. This study provides several implications for teacher education and research.

LIST OF ACRONYMS AND ABBREVIATIONS

BEd	Bachelor of Education
BEd(Hons)	Bachelor of Education honours
CAPS	Curriculum Assessment Policy Statement
DBE	Department of Basic Education
DoE	Department of Education
EQUIP	Electronic Quality of Inquiry Protocol
HOD	Head of Department
IBI	Inquiry-based instruction
NCS	National Curriculum Statement
NDP	National Development Plan
NGSS	Next Generation Science Standards
NRC	National Research Council
PCK	Pedagogical Content Knowledge
SRI	Stimulated Recall Interview
TBI	Teacher Beliefs Interview
TBS	Teacher Beliefs Study
TGI	Teaching Goals Inventory
POSTT	Pedagogy of Science Teaching Test
TSPCK	Topic-Specific Pedagogical Content Knowledge

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CHAPTER ONE
ORIENTATION TO THE STUDY

1.1 Introduction

Access to quality education for learners is stated as a fundamental human right in the Republic of South Africa's constitution and a fundamental precondition for achieving the National Development Plan (NDP) 2030. The vision for the NDP is that by the year 2030, South Africans must have a basic education of the highest quality that will equip them with life-changing skills and knowledge (National Planning Commission, 2012). In the NPD, there are statements about good sciences and technology education being crucial for South Africa's future innovation to address the economy, develop skills, create jobs, and eradicate poverty and unemployment. So for this to be achieved, as indicated in the NDP, highly competent science, technology, and mathematics teachers are required. Jones and Leagon (2014) agree that high-quality teachers are the most important factor in driving the quality of science education. Also, the quality of science instruction positively impacts the scientific and technological literacy of the general population. In advancing education reform, inquiry-based science has been advocated as desirable for school science curricula. Recently research findings in science education point to the importance of Inquiry-based instruction (IBI) to improve science teaching and learning (Kind, 2016). But, in the South African context, IBI is rarely implemented in sciences classrooms (Nhase et al., 2021; Ramnarain & Hlatswayo, 2018; Sondlo & Ramnarain, 2021). A review of the literature indicates that several factors influence why teachers teach the way they do, and among the most cited reasons contributing to the lack of IBI are teacher beliefs and goals. This study explored the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices.

This introductory chapter thus provides an overview of this study, as it seeks to understand the relationship between novice physical sciences teachers' beliefs and goals to IBI practices. The chapter starts by providing contextual background information relevant to the study. It briefly describes the IBI practices as a transformed South African curriculum requirement and presents a detailed description of the study's research problem, purpose, significance, and rationale. It further highlights a brief overview of the methodological approaches adopted in this empirical study. The chapter concludes with an outline of the structure of the thesis.

1.2 Background of the study

IBI is crucial for twenty-first-century science teaching, especially in many science curricula developed recently (Marshall et al., 2017). An improvement in science instruction through reformed science pedagogy is recommended in international and national policies (i.e., Curriculum and Assessment Policy Statement [CAPS], Department of Basic Education [DBE], 2011; National Research Council [NRC], 1996, 2000, 2012; Next Generation Science Standards [NGSS], 2013). IBI is acknowledged as a teaching pedagogy that facilitates critical, deep thinking in learners and can promote a meaningful understanding of science concepts (DBE, 2011; NRC, 1996, 2000, 2012; NGSS, 2013). Science education reform movements have long focused on improving science curricula, student learning, and science teaching through IBI implementation. IBI has become widely advocated in science education standards and, consequently, in teacher preparation programmes in many countries and has been emphasized as part of the educational reforms in the South African curriculum.

In South Africa, the National Curriculum Statement (NCS) (Department of Education [DoE], 2003) publication endorsed an inquiry-based science curriculum intended to transform teachers' classroom practices and the learners' learning environments. This imperative was also expressed during curriculum reform in the new CAPS document, which gave more detailed guidance regarding what teachers need to teach and assess (DBE, 2011, p. 8). CAPS asserts that physical sciences teaching should be done through scientific inquiry and the application of scientific models, theories, and laws in order to predict events in the physical environment (DBE, 2011). The place of inquiry is addressed through specific aims in CAPS, which emphasise that physical sciences must 'promote knowledge and skills in scientific inquiry and problem-solving' and that learners need to be 'equipped with investigating skills relating to physical and chemical phenomena' (DBE, 2011, p. 8). The CAPS document does not contain a precise definition of inquiry teaching; however, it includes examples that frame inquiry as scientific practices similar to the actual work of scientists (DBE, 2011). Table 1.1 indicates the similarities and focus between physical sciences CAPS and IBI outcomes. As indicated in Table 1.1, the characteristics of IBI are compiled from reviewing the literature (Marshall et al., 2010, 2011, 2017).

Table 1.1

Alignment between CAPS physical sciences and IBI

NCS CAPS- physical sciences	**IBI**
Promotes learner-centred teaching and learning	Learners are not empty vessels that need to be filled; instead, their existing knowledge serves as an important foundation for new learning
Promotes active learning	Learners are active participants. Learning is the active process of constructing knowledge
Promotes construction of knowledge	Learners actively construct meanings and knowledge and make sense of the world
Encourages learners to identify and solve problems using critical and creative thinking	Learning tasks should be framed as a problem-solving activity that requires developing and using higher-order thinking skills.
Encourages learners to work effectively with others as a member of the group	Learners should be working cooperatively with fellow students and interacting with their instructor.

The features of IBI in Table 1.1 require physical sciences teachers to guide learners through inquiry processes that mirror the practices of scientists. Physical sciences teachers should be capable of using various IBI strategies to allow learners to understand scientific concepts through investigations. In addition, learners should be able to plan and conduct scientific investigations and construct their knowledge and better understanding through scientific inquiry. IBI replaced the traditional, textbook-driven, rote science instruction and learning mode.

This study borrowed from Crawford and Capps's (2018) IBI definition of the pedagogy by which teachers engage learners in inquiry. According to Crawford (2014, p. 515), 'teaching science as inquiry involves engaging students in using critical thinking skills, that includes asking questions, designing and carrying out investigations, interpreting data as evidence, creating arguments, building models, and communicating findings, in the pursuit of deepening their understanding by using logic and evidence about the natural world.' IBI, in this study, refers to classroom instruction that promotes more than just knowledge and skill development but allows learners to engage in the practices of science. This can facilitate learners' development of conceptual understanding of scientific ideas as they make observations, pose questions, examine a range of sources of information, and get involved in first-hand experiences with materials to gather, analyse, and interpret data; propose answers, explanations, and predictions; and develop scientific attitudes (DBE, 2011; Capps & Crawford, 2013; Marshall et al., 2017; NRC, 1996; NGSS, 2013).

1.3 Statement of the problem

The researchers and experts in science education have expressed concerns that despite some years of promoting IBI, many sciences teachers still use traditional methods in their classrooms (Aubusson et al., 2015; Hutner & Markman, 2017; Mokiwa, 2014; Nhase et al., 2021). IBI is not implemented in many science classrooms, and its use has remained the exception rather than the norm (Dudu, 2014; Mokiwa, 2014; Ramnarain et al., 2016; Ramnarain & Hlatswayo, 2018; Ramnarain & Schuster, 2014). This study stemmed from apprehensions among researchers that transformation efforts based on promoting IBI as the basis for teaching science have not achieved the desired changes in South African science classrooms. The challenge of IBI is not a central issue in South Africa but is reported worldwide, even in developed countries such as the United States, United Kingdom, Canada, and Australia (Aubusson et al., 2015; Kim & Tan, 2011; Hutner & Markman, 2017; Sun et al., 2014). The state of affairs is that many sciences teachers have difficulty implementing IBI (Crawford & Capps, 2018; Hutner & Markman, 2017; Luft, 2009; Luft et al., 2011; Ozel & Luft, 2013; Ramnarain & Hlatswayo, 2018).

Research studies provide myriad reasons for the lack of IBI in science classroom practice. Science teachers' traditional beliefs about teaching and learning (Fives & Buehl, 2016; Pajares, 1992; Roehrig & Luft, 2004), teachers' negative beliefs about inquiry (Saad & Boujaoude, 2012), inadequate knowledge of the practice of science (Mokiwa, 2014; Saad & BouJaoude, 2012), lack of pedagogical skills (Adams & Krockover, 1997; Crawford, 2007; Kang et al., 2013) and inadequate preparation in science (Pilitsis & Duncan, 2012) are the main reasons for the lack of IBI in science classrooms. Hence, it appears that critical to implementing IBI are science teachers' fundamental knowledge and beliefs in the value of this approach.

The science education literature agrees that science teachers' classroom instructional practices are heavily influenced by their knowledge and beliefs (Lebak, 2015; Luft, 2009; Luft et al., 2011; Ozel & Luft, 2013; Wong et al., 2015). These studies examining science teachers' knowledge and beliefs to their classroom practice have yielded mixed results (Blignaut, 2011; Capps & Crawford, 2013). Some studies indicate that, even though science teachers have the knowledge and believe in learner-centred instructional practices, they often default to more traditional methods, which are teacher-centred (Capps & Crawford, 2013; Crawford, 2007; Mokiwa, 2014). Other studies indicate those science teachers with knowledge and beliefs about learner-centred instructional practices will use them upon entering the classroom (Mansour, 2013; Pilitsis & Duncan, 2012). Attempts have been made to explicate the contradiction between teachers' knowledge and beliefs about IBI using different theories of teacher beliefs and their classroom behaviour (Adams & Krockover, 1997; Borg, 2015; Hutner & Markman, 2017; 2008; Mansour, 2013; Pajares, 1992). However, these studies assumed, tacitly or not, that a direct relationship exists between teachers' beliefs and their classroom practices. The consistencies and inconsistencies that have been observed between science teachers' beliefs about IBI to their classroom practice have made it difficult to delineate a direct relationship between science teachers' beliefs and IBI.

However, there is growing recognition that knowledge and beliefs may not be the sole determinants of classroom practice. Schoenfeld (1998, 2010) added goals, revealing that classroom practice is modelled by teachers' knowledge, beliefs, and goals. Similarly, Groth (2010) considers goals as influential to classroom action and refers to teachers' goals, knowledge, and beliefs as the overarching cognition[1] in shaping classroom practice. Recently, Hutner and Markman (2017) also pointed out that classroom practice is more likely to be consistent with science teachers' goals. Beliefs - practice inconsistency paradox has prompted the push of boundaries to explore the role of science teachers' goals in their classroom practice (Fairbanks et al., 2010; Mansour, 2013). While the literature explains the relationships between beliefs and practice, the relationship between goals and practice is just minimal (not yet known). This raises the question of how beliefs and goals influence sciences teachers' IBI classroom practices.

1.4 The purpose of the study

The purpose of this multiple-case qualitative study was to understand the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices. To be able to capture this relationship, the focus was on the role of teachers' beliefs and goals in IBI practices.

[1] Teacher cognition is regarded as a set of processes that is knowledge, beliefs and goals that act over mental representations to produce thoughts and action (Hutner & Markman, 2017). In this study, teacher cognition will refer to the relation of teachers' beliefs and goals to classroom practice.

Exploring the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices enabled this study to provide additional leverage points in an effort to improve the quality of science teaching. Being able to describe the relationship between teachers' beliefs and goals to their classroom practice deepened and enriched the understanding of novice teachers' teaching process (Aguirre & Speer, 2000). Furthermore, it enriched the understanding of how teacher beliefs and goals influenced IBI practices.

Despite an increased interest in IBI, much of the research work has focused on the role played by science teachers' knowledge and beliefs in classroom practice (Adams & Krockover, 1997; Borg, 2015; Hutner, 2015; Kleickmann et al., 2013; Pajares, 1992). Very few studies have taken a systemic look at the role of science teachers' goals about IBI in their classroom practice (Han et al., 2015; Schoenfeld, 2011; Skaalvik & Skaalvik, 2013). However, what remains to be explored is the relationship between science teachers' beliefs and goals about IBI classroom practice. Kang (2008) and Shaffer et al. (2019) point out that understanding teachers' instructional actions through their goals can serve as a window into teachers' classroom practice. Goals have been valuable in other professional literature, e.g., in medicine, nursing, career, and life, to develop an understanding of occupational engagement and career success. However, limited literature discusses how teaching goals may have either a sustaining or limiting impact on teachers' careers. Therefore, this study aims to address this gap in the literature by exploring the relationship between novice physical sciences teachers' beliefs and goals about IBI to their classroom practice.

Fullan (2001) points out that educational change depends on teachers' actions and thoughts. Likewise, Meijer et al. (2009) state that exploring teacher cognition about IBI is an important attempt to improve science teachers' classroom behaviour. Similarly, Baumert et al. (2010) believe that research on teacher classroom practice needs to elaborate on teacher knowledge, beliefs, and instructional goals[2]. Instructional goals in this study are the goals of teaching science that a teacher with a particular orientation would have (Magnusson et al., 1999). There is a vital need to understand how teachers think and work within an education system. This understanding will explain science teachers' classroom practice and what aspect of cognition, beliefs, or goals about IBI helps explain science teachers' classroom practice.

[2] The terms instructional goals, teaching goals and goals will be used interchangeable in this study.

1.4.1 Critical questions

To understand the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices, this study posed the following main questions: *What is the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices?* In pursuit of addressing the main question, the study addressed three critical sub-questions:

1. What beliefs and goals do novice physical sciences teachers hold about IBI?
2. How do novice physical sciences teachers' beliefs and goals relate to their IBI practices?
3. Why do novice physical sciences teachers' beliefs and goals relate to their IBI practices in the manner that they do?

1.5 Rationale

A research study rationale addresses how the researcher developed an interest in the topic and why the study is worth doing (Cohen et al., 2018). My interest in this study stemmed from my personal observation and literature. For the past twenty years of practical experience as a physical sciences teacher and a head of department (HOD) for sciences, I have observed that novice physical sciences teachers use traditional teaching methods when joining our school. This was not what I anticipated, assuming they have recently come from the university and have studied new reformed physical sciences teaching approaches. In the science department, we had formal quarterly meetings that discussed departmental issues, such as learners' performance and teaching for conceptual understanding. During the discussions, the novice physical sciences teachers mentioned learner-centred approaches and promoted teaching for conceptual understanding. The discussions revealed that they have the knowledge of and understand these approaches. Even during the informal discussions, they revealed learner-centred knowledge but used teacher-centred approaches when teaching. I had this question in my mind of why these teachers are not using the learner-centred approaches they learned from the teacher training programmes.

In 2015 I joined a tertiary institution as a lecturer in physical sciences education. I taught one of the physical sciences method modules to the pre-service teachers. Some of the topics involved the discussion of the South African physical sciences curriculum (i.e., CAPS), learning theories, Inquiry-based science teaching, and others. During the teaching and learning of the module, pre-service science teachers revealed their knowledge about and believed in using inquiry-based science teaching and learning. However, during school visits for teaching practice, I observed that most used traditional, teacher-centred methods. Also, I observed that the pre-service physical sciences teachers implement IBI practices differently. My observation was not what I anticipated of them not using IBI in teaching and learning physical sciences. My observation at the school level and as a lecturer motivated me to conduct this research study to explore why novice physical sciences teachers teach the way they do, even after knowing about IBI. To inform my professional practice as a physical sciences lecturer, I decided to explore the relationship between teachers' beliefs and goals to IBI practice.

Research studies on teacher knowledge, beliefs, and goals have captured the complexities of who teachers are, what they know and believe, and what they do in the classroom. According to Borg (2009), studying teachers' cognition helps uncover what teachers know, believe, and think about innovation and how their knowledge, beliefs, and thinking inform teaching. Thus, exploring teacher cognition is a common lens to understand science teachers' classroom actions or behaviour (Hutner & Markman, 2017). Some studies in science education have taken a systemic look at teachers' knowledge, beliefs, and goals to classroom practice (Aguirre & Speer, 2000; Chen et al., 2009; Han et al., 2015; Mansfield et al., 2012; Schoenfeld, 2008; Skaalvik & Skaalvik, 2013). However, minimal of these studies have focused on teachers' goals and IBI. Hence, there is a need to study novice physical sciences teachers' cognition about IBI practices.

Furthermore, many research studies focused on pre-service or in-service science teachers to explore the role of beliefs and goals in classroom practice. Scant attention, especially in South Africa, where this study took place, had been paid to novice physical sciences teachers' beliefs and goals about IBI (Luft, 2009; Luft et al., 2011; Ozel & Luft, 2013). While little is known about novice physical sciences teachers, this study sought to address the gap on how novice physical sciences teachers' beliefs and goals relate to their IBI classroom practice. Novice physical sciences teachers are seen as a great hope, and a means for producing reform in science teaching. Davis et al. (2006) argue that novice science teachers are critical for implementing a reform-based curriculum and are most likely to espouse and encourage reform-oriented instruction. Most novice teachers are idealistic and optimistic about their first years of teaching. They begin the new teaching career with personal beliefs, attitudes, and a sense of various roles they feel that they have to play as teachers.

Stanulis et al. (2012) argue that the first years of teaching are critical in teachers' working lives because they implement and refine the knowledge and skills they acquired from their initial teacher education programme. On the contrary, other researchers indicate that novice science teachers quickly discard what they have learned from the teacher education programme, reformed-science teaching, and revert to traditional, didactic approaches (Gunckel & Wood, 2016; Hutner & Markman, 2017; Luft & Roehring, 2007; Ramnarain & Hlatswayo, 2018). The contradicting findings in the literature about novice teachers had also motivated me to purposefully select novice physical sciences teachers. Moreover, Bryan (2003) argues that the beginning years of teaching are the ideal time to explore beliefs because the initial stages of a teacher's career may reveal a range of beliefs and goals about IBI and various classroom practices.

1.6 Significance of the study

The study on the relationship between novice physical sciences teachers' beliefs and goals to IBI practices led to significant conclusions after answering the research questions. The research gap on improving physical sciences teachers' classroom practice persists despite the refinement of theories of learning and teaching and the empirical evidence that supports effective teaching practices. Some researchers have argued that the difficulties of changing teaching practices are due to a lack of alignment between teachers' beliefs and classroom practices. Even though a growing body of research has explored the relationship between beliefs and classroom practices, contradictions still exist (Lebak, 2015; Luft et al., 2015; Hutner & Markman, 2017; Wong et al., 2013). Moreover, several studies have revealed that more than teacher beliefs, teachers' practices are also influenced by factors such as their pedagogical orientation, school context, subject matter, academic requirements, overcrowded classrooms, and self-efficacy, among others (Buehl & Beck, 2015; Fletcher & Luft, 2011; Sondlo & Ramnarain, 2018, 2021). However, little is known about the relationship between the goals teachers pursue in their teaching practices and how these goals influence their teaching practices. This study addressed and will also fill this research gap in the literature by exploring the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices.

Apart from the potential to address research gaps, the current study aimed to contribute to science teachers' cognition in numerous areas. Despite its recognized importance, the research avenue on the relationship between teachers' beliefs and goals to IBI had not been well-established in South Africa. Therefore, understanding how and to what extent science teachers' beliefs and goals were influential in IBI implementation shed light on physical sciences teaching. Given that IBI in South Africa is multifaceted and complex, this understanding could lead to improvements in pre-service and in-service science teacher professional development to be better prepared to implement IBI. Understanding novice physical sciences teachers' beliefs and goals about IBI to their classroom practice could help in determining the types of experiences that are important for novice sciences teachers as they progress through their careers. Thus, this study provided a framework to help understand the consistencies and inconsistencies in the science teachers' beliefs and goals-practice relationship.

These findings could be helpful for educational policymakers, curriculum developers, practitioners, and teacher educators within the context of curricular reform. While social and educational research may not reveal the ultimate truth due to its complexity, it does help us understand and make sense of our educational settings (Babbie, 2010). Thus, exploring teacher cognition helped identify elements of behaviour that explain the specific processes in the mind of the science teachers that trigger some classroom practice and contextual factors that might give rise to observed classroom behaviour. The research literature suggests that teaching context plays an influential role in some classroom practices. This research was valuable because it yielded new insights into physical sciences teachers' beliefs and goals regarding the knowledge gap.

1.8 Methodological approach

I adopted the social constructivism paradigm to understand the role of beliefs and goals on IBI practices from more than one perspective. The social constructivism paradigm is based on the premise that individuals seek multiple, subjective understandings of the world in which they live and work (Creswell & Poth, 2018). It advocates that human beings humans are capable of creating their own meaning based on their experiences. It is concerned with meaning-making and seeks to understand the subjective world of human experiences (Cohen et al., 2018). The social constructivism paradigm allowed me to seek in-depth accounts of the novice teachers' experiences of the phenomenon under study. Guided by the social constructivist views, I adopted a qualitative research approach to data gathering and analysis. The qualitative approach was used as it concerns specific meanings, emotions, and practices that emerge through the interactions between people. I used the qualitative approach to get an in-depth understanding as it provided the data needed to answer the critical research questions.

I decided to employ a case study design. The case study explores different cases using a variety of sources of information (Creswell & Poth, 2018). A multiple-case study was the best means to answer the research questions as they allow for descriptions and interpretations. Purposive sampling was used to select the four novice physical sciences teachers. One of the strengths of case study design is allowing the researcher to use various research data gathering techniques. I used open-ended questionnaires, classroom observations, and stimulated recall interviews to collect data for this study. Additionally, I collected artefacts from novice teachers to understand their IBI practices. Qualitative Framework data analysis includes noting patterns, themes, categories, and regularities. I presented, analysed, and discussed data and findings according to each research question. The research design and methodology utilised in the study are discussed in greater detail in chapter four of this thesis.

1.9 Overview of the study

In **Chapter One**, I introduced and contextualised the research study. I outlined the problem statement and the rationale for this study. I indicated that IBI is acknowledged as a teaching pedagogy to improve science education. It facilitates critical, deep thinking in learners and can promote a meaningful understanding of science concepts. It is one of the instructional strategies born from constructivism. However, novice teachers continue to rely on traditional, teacher-centred approaches in physical sciences classrooms. Unfortunately, IBI is rarely implemented in science classrooms. Teachers' beliefs and goals were among the myriad reasons for the lack of IBI and the main drivers of teachers' classroom practice. I formulated the research questions to explore the relationship between novice teachers' beliefs and goals to their IBI practice to understand why teachers teach the way they do. Lastly, I discussed a brief overview of the research design in the chapter, including ethical issues.

Chapter Two reviews the literature that relates to teachers' beliefs, goals, IBI, and classroom practices related to IBI. I commence the chapter with an in-depth analysis of teachers' beliefs and goals, focusing on their meanings and the context in which they are used, considering their multiple conceptions. This discussion is informed by the view that teachers' beliefs and goals are sometimes considered the same, different, or subsumed in each other. Informed by the literature reviewed, I realised that beliefs are distinct mental representation from goals representation. Furthermore, the literature suggested that environmental factors form and shape science teachers' teaching and learning beliefs and goals. These can be physical factors such as school, classroom, and resources or social factors such as policy, time, and department subculture. Following this was the discussion of the meaning of IBI and its classroom practice. Finally, I reviewed studies on teaching and learning beliefs and goals and paid attention to their relationship to classroom practice. This literature review is informed by the view that teachers' beliefs and goals impact their classroom practice. The studies indicated the discrepancy that still exists between teachers' beliefs and goals to classroom practice. Most of the studies attributed the belief-practice mismatch to social and physical factors.

In **Chapter Three**, I present the two theoretical frameworks which informed data gathering and the analysis in the study. The first one was the constructivist theory of learning (Dewey, 1933; Piaget,1936; Vygotsky,1978; and von Glasersfeld, 1995) which informs teachers' beliefs, goals, and classroom practice related to IBI. Since IBI was born out of constructivism, the discussion about the constructivist teaching environment, teacher roles, beliefs, and goals also applied to it. The focus on the constructivist teacher beliefs, goals, and environment was informed by the view that teachers' beliefs and goals impact their classroom practice.

The second framework was the goal-driven teacher cognition model (Hutner & Markman, 2017), which explained the relationship between mediating, goal, and environmental representation in teachers' cognition. I used it to explain the relationship between beliefs, goals, and contextual factors in novice teachers' classroom actions or behaviour. The theory posits that teacher cognition is goal-driven, and the beliefs and contextual factors mediate the selection of goals to be pursued. I fused the two frameworks to provide a lens to explore why novice physical sciences teachers teach the way they do. The frameworks provided evidence that the teachers' adoption of teacher-focused goals may contribute to the lack of IBI in science classes.

In **Chapter Four,** I provide a comprehensive methodological orientation to the study and analysis discussion. I discuss social constructivism as my research paradigm and the qualitative approach for data gathering. I adopted a multiple case study to understand the relationship between novice physical sciences teachers' beliefs and goals to IBI practice. I selected participants, novice physical sciences teachers, using purposive sampling. I discussed the data gathering process to determine their beliefs and goals. I used constructivist-aligned instruments such as the Teacher Beliefs Interview (TBI), Pedagogy of Science Teaching Test (POSTT), Teaching Goals Inventory (TGI), and Electronic Quality of Inquiry Protocol (EQUIP).

To triangulate the data from these instruments, I conducted stimulated recall interviews (SRI) after all classroom observations. SRI also assisted me in understanding why novice teachers do what they do in the classroom (i.e., their actions). SRI allowed me to see the classroom practices through the novice teachers' eyes when explaining their inquiry-based practices during a classroom observation. Moreover, novice physical sciences teachers verbalised their thoughts on their beliefs and goals about IBI. Finally, in this chapter, I discussed the study's trustworthiness and ethical considerations that were taken into consideration.

Chapters Five to Eight focus on case-by-case data presentation for each novice physical sciences teacher. I present the findings from the data obtained for each case according to research sub-questions. Chapter five presents Nelisa, who held learner-centred responsive beliefs. She had a learner-focused overarching guided inquiry goal. Her IBI practice was rated at level three, proficient inquiry. In chapter six, I present Wayde's case. Wayde held traditional teacher-centred beliefs, teacher-focused overarching active direct goal, and pre-inquiry classroom practice at level one. I present Amalia's case in chapter seven and Gatsha's in eight. The analysis revealed that Amalia and Gatsha had the same teacher-centred instructive beliefs and teacher-focused, active direct goals. Their IBI practice was rated at level two, developing inquiry.

In **Chapter Nine**, I present the interpretation of the findings through the cross-case analyses of the four cases. I interpreted and discussed these findings in chapter nine. The interpretation and discussion of the novice teachers' trends identified above were then related to the literature and the frameworks.

Chapter Ten concludes the study by developing implications for policy, practice, and further research from the findings. Teacher cognition research investigates or explores teachers' thought processes and thus represents a shift in focus from searching for better ways to train teachers and understanding how teachers learn to teach.

CHAPTER TWO
A REVIEW OF THE LITERATURE

2.1 Introduction

In chapter one, I revealed that there is a common consensus that beliefs and goals are central to teacher cognition and strongly influence the decisions they make regarding classroom instruction (Capps et al., 2016; Hutner & Markman, 2016, 2017; Luft et al., 2015; Wallace, 2014). Even though teacher beliefs and goals are a well-established research area, the dynamic interactions between teachers' beliefs and goals to their classroom practice still need to be clearly understood. In this literature review, I delineate the relationship between teachers' beliefs and goals to IBI practices based on the mentioned argument. I review international and South African literature on teacher beliefs, goals, and IBI classroom practice. The chapter is organised into four sections. I begin with an overview of the literature on beliefs, then teacher goals as mental constructs to teacher cognition. I then discuss IBI classroom practice. The final section reviews the previous studies on how beliefs and goals translate to classroom practice. The final section presents the conceptual framework of this chapter that has informed my understanding of the relationship between beliefs and goals about IBI to classroom practice.

2.2 Science teacher beliefs

Studying teacher beliefs is complicated due to a lack of agreement about clear definitions and perspectives, as there are conflicting definitions and different perspectives on the relationship between knowledge, beliefs, and goals. This section is essential to better clarify the term and definition of beliefs and understand the relationship between teacher beliefs and IBI practices. In this section, I discuss the definitions, nature, sources, and types of beliefs in literature and explain distinctions between beliefs and other constructs, such as knowledge.

2.2.1 Teacher beliefs: meaning

In a synthesis of research about beliefs, scholars have recognised the difficulty of defining beliefs as different terms have been used, leading to different and multiple interpretations (Hutner & Markman, 2016; Jones & Leagon, 2014; Kagan, 1992; Mansour, 2013; Pajares, 1992). Jones and Leagon (2014) and Pajares (1992) regarded teachers' beliefs as a 'messy construct' (p.307) because beliefs are difficult to define and elicit. Pajares (1992, p. 307) declared that 'the difficulty in studying teachers' beliefs has been caused by definitional problems, poor conceptualizations, and differing understandings of beliefs and belief structures.' One confusion in the meaning of beliefs generally concentrates on distinguishing between other similar constructs such as knowledge, disposition, identities, or goals (Hutner & Markman, 2016). Some scholars had an understanding that teacher knowledge and beliefs cannot be separated since these terms are blurry and treat these mental constructs as similar. In the nineties, Pajares (1992) stated that 'knowledge and beliefs are inextricably intertwined' (p. 19). Kagan (1992) agreed that what is considered professional knowledge could be categorised as beliefs, and many similarities are evident by reflecting on teachers' pedagogical knowledge and beliefs. Similarly, Bryan (2012) stated that teachers' knowledge and beliefs are interwoven, hard to disentangle, and blurred. Fajardo (2013) supported this view and adopted 'systems of knowledge and beliefs as an inclusive term that implies the connection between teachers' beliefs and teaching practices.

Other scholars treated beliefs and knowledge as separate. For example, Nespor (1987) argued that beliefs have stronger affective and evaluative loading since beliefs are more powerful in influencing classroom practice than knowledge. A similar argument was raised by Richardson (2003), making a distinction between knowledge and beliefs on the basis that beliefs do not require epistemic warrant while knowledge does. Mansour (2009) provided a further distinction between beliefs and knowledge. He explained that 'while knowledge often changes, beliefs are static, whereas knowledge can be evaluated or judged, such is not the case with beliefs since there is usually a lack of consensus about how they are to be evaluated' (p. 27). Talbot and Campbell (2014) distinguished between knowledge and beliefs and argued that beliefs were based on evaluation and judgment, while knowledge was based on objective fact. Howard (2014), though, has argued that teaching beliefs are quite different from teaching knowledge but agreed that it would be a mistake to separate the two because teaching beliefs may perhaps best be viewed as a window through which one can interpret teaching knowledge.

Due to the difficulty of defining beliefs, some researchers use terms that subsume both knowledge and beliefs under the same umbrella. For example, Borko and Putnam (1996) and Magnusson et al. (1999) used orientations toward teaching science when referring to the interplay of teachers' knowledge and beliefs about scientific inquiry. Magnusson and colleagues defined orientations as the knowledge and beliefs about the purposes and goals for teaching science to specific age groups. Scholars have used science teaching orientation to refer to beliefs, knowledge, or goals. For example, Maseko and Khoza (2021) have used the term orientations to refer to beliefs in their study exploring the influence of science teaching orientations on teacher professional knowledge. Crawford (2007) uses the term ‘views’ to describe the interplay of teacher knowledge of scientific inquiry and pedagogy and beliefs of science learners. Recently Kind (2016) justified the inclusion of both knowledge and beliefs in science teaching orientations, given the uncertainty in the definition of these terms.

Although the definition of teacher beliefs is not consistent due to how beliefs are referred to in educational research, it is important to define the concept when used for research studies (Luft & Roehrig, 2007). In the early eighties, beliefs were regarded as dispositions to action and the main determinants of behaviour (Abelson, 1979). Pajares (1992, p. 316), based on her extensive review of the literature, defined belief as an ‘individual’s judgment of the truth or falsity of a proposition, a judgment that can only be inferred from a collective understanding of what human beings say, intend, and do.’ In agreement with this definition, Kagan (1992) defines beliefs as the highly personal ways a teacher understands classrooms, learners, the nature of learning, and the teacher’s role in the classroom. Mansour (2013) agrees with Kagan and regards beliefs as filters through which information passes to interpret new experiences. Recently, Hutner and Markman (2016) define beliefs as mental representations that influence a teacher’s practice if and only if the belief is active in cognition. Hutner and Markman’s definition of beliefs is similar to how Dewey defined beliefs in the nineties. Dewey (1933) considers beliefs as a term that covers all the matters we have no sure knowledge of and yet which we are sufficiently confident to act upon and the matters that we now accept as certainly true. Their definitions are similar in that they consider beliefs to influence behaviour when activated into action.

The focus of this study is not on the teacher’s beliefs meaning or the distinction between beliefs and knowledge. However, the focus of the study is on the role played by beliefs on classroom practice related to IBI practices. Therefore, I subscribed to Hutner and Markman’s (2016, 2017) definition of beliefs because it acknowledges the function that beliefs play in teacher cognition. Moreover, according to Hutner and Markman (2017), the role played by knowledge and beliefs in teacher cognition leading to classroom practice is the same. This explanation makes the issue of distinction less relevant in this study. The answers to my research questions will be informed by novice physical sciences teachers’ beliefs and their role in cognition leading to IBI practices.

Using Hutner and Markman's (2017) definition, this study seeks to extend to the literature on how beliefs are activated in sciences teacher cognition to influence classroom practice.

2.2.2 Sources of teacher beliefs

Researchers have identified the potential sources of teacher beliefs even though it is difficult to pinpoint where they come from. Teacher beliefs may develop due to personal life experiences as learners, schooling experiences including pre-service education, formal knowledge of their own teaching experience, and observation of other teachers (Levin et al., 2013). Also, Buehl and Fives (2009) identified six sources for teachers' epistemological beliefs, matching some identified by Bryan (2012). Those belief sources included formal education, formal bodies of knowledge, observational learning, collaboration with others, personal teaching experiences, and self-reflection. According to Buehl and Fives (2009), the schooling experience develops images of good science for pre-service teachers by emulating the practices of their science teachers. Bryan (2012) furthermore indicated that prospective science teachers' beliefs are formed from years of experience as a science learner, an observer of the profession, a participant in education courses, and limited experiences as science teaching professionals (e.g., teaching practice and tutoring). According to Pajares (1992), beliefs formed at an early stage (i.e., from schooling experience) are well established by the time students attend college, making them difficult to change. Belo et al. (2014) attested to the assumption that teacher beliefs are well established by the time pre-service teachers enter teacher education and start their educational careers.

The research studies conducted with pre-service sciences teachers indicated that teacher education might have a feeble impact on student teachers' beliefs (Hudson et al., 2010; Levin et al., 2013; Löfström & Poom-Valickis, 2013). Hudson et al. (2010) reinforce the view that pre-service teachers already have vast experience in teaching and learning when they start their teacher education. For example, Löfström and Poom-Valickis (2013) concluded in their study that while some pre-service teachers adopted new beliefs consistent with the theory of the course, they still held on to some of their former beliefs. Moreover, Levin et al. (2013) found that novice teachers attributed their pedagogical beliefs primarily to their experiences as grade 1-12 learners and what they learned during their teacher education program. Also, Schneider and Plasman (2011) found that pre-service biology teachers were greatly influenced by their beliefs formed from their own experiences from formal education as learners and not just by the knowledge learned in their initial teacher education. Therefore, research studies stressed the importance of identifying sources of teacher beliefs because they may have an influence on whether or not beliefs are changeable and how they develop over time (Levin et al., 2013).

Although there are discussions about teachers' beliefs regarding resistance to change, other researchers demonstrated that beliefs could change. Belo et al. (2014) referred to the 'stability' assumption as the resistance of beliefs to change. They further assumed that novice teachers' beliefs are less stable and less resistant to change when compared to experienced teachers. Fives and Buehl (2016) supported that beliefs exist on a continuum of stability where some beliefs are resistant to change, and others are susceptible to change. For example, Southerland et al. (2011) suggested that teacher beliefs can change and move toward supporting reform-based practices with sustained effort and support. Similar to Pilitsis and Duncan (2012), who revealed a change in beliefs that pre-service teachers progressed in their orientation beliefs from a teacher-centred orientation to a more student-centred orientation in their study.

The positive change in teachers' beliefs from Pilitsis and Duncan's (2012) study resulted from a professional development course, and the negative change from Levin et al. (2013) was due to contextual factors. In discussing teacher beliefs change, Levin et al. (2013) observed that novice teachers discarded their enthusiasm for differentiated learning because it conflicted with school norms that emphasised drilling students using past examination items in preparation for high-stakes exams. The influence of contextual factors on teacher beliefs was supported by Saka et al.'s (2013) study. They established how the power of cultural context, i.e., school administrators, peer teachers, learners, and classroom designs, compels novice teachers to abandon the reform-based practices they acquired during teacher education.

Mansour (2009) called for attention to contextual factors and argued that teachers' beliefs could not be examined out of the social-cultural context since they are directly espoused from their background and culture. Adding on the cultural factors identified to influence teacher beliefs and classroom practice, he included prescribed curriculum, time constraints, pacing plans, high-stakes examinations, lack of administrative support, and lack of expertise and resources. Fives and Buehl (2012) asserted that beliefs are also influenced by the goals of society, the nature of the curriculum, and the relationships of teachers in the school community, after reviewing more than six hundred research articles about teachers' beliefs. From the above discussions, one may infer that beliefs of resistance or no resistance to change may depend on contextual factors that novice teachers encounter during their first years of teaching, including classroom, school, and district factors. Therefore, understanding novice teachers' context when studying beliefs is paramount because teachers' beliefs and actions cannot be separated from situations in which they occur.

2.2.3 Nature of teacher beliefs

Several research studies have proposed that teacher beliefs exist as a system (Aguirre & Speer, 2000; Belo et al., 2014; Bryan, 2003; Nespor, 1987; Pajares, 1992). Commenting on beliefs as a system, Pajares (1992, p.325) concludes that 'belief sub-structures, such as educational beliefs, must be understood in terms of their connections not only to each other but also to others, perhaps more central, beliefs in the system.' Aguirre and Speer (2000) refer to belief systems as belief bundles, collection of beliefs, or multiple beliefs. According to Aguirre and Speer, a belief bundle can be a number of beliefs about teaching, learning, science, etc., that go together. In agreement with Aguirre and Speer's explanation, Bryan (2003) described teacher beliefs as nested, meaning a set of beliefs connected or integrated into one tightly-held system. Bryan even resembles the interwoven, nestedness of beliefs as the twigs that comprise a bird's nest. Luft and Roehrig (2007) concur that beliefs exist as a system and are nested within each other. According to them, when beginning science teachers discuss learning, they often make connections to learners' knowledge. These connections are important as they contribute to a more holistic view of teaching and learning beliefs.

Teachers' beliefs in a system can be competing or in conflict. Davis et al. (2006) found that novice teachers hold beliefs that are in conflict with other beliefs when put into practice. When this happens, one belief may trump another, sometimes leading to less sophisticated teaching practices. Similarly, Crawford (2007) found that teachers may hold conflicting beliefs. On the one hand, they may believe that an inquiry-based approach supports learner critical thinking and promote conceptual understanding of science, while on the other hand believe that it promotes the transmission of knowledge and coverage of content. For example, in his study examining the complex relationship between teacher beliefs and practice, Lebak (2015) found that Jerry's beliefs regarding his learners' capabilities trumped other beliefs consistent with an inquiry-based approach. Guerra and Wubbena (2017) explained the disjoint between conflicting beliefs and practices using the cognitive dissonance theory. They suggested that educators must help teachers understand how to cope with the complexities of classroom life and how to apply theory within the constraints imposed by those realities.

2.2.4 Types of teacher beliefs

Teacher beliefs have been studied and classified into different models or types. The broad types relevant to teacher beliefs related to science teaching can be divided into pedagogical beliefs and beliefs about the subject matter (Pajares, 1992; Jones & Carter, 2007; Jones & Leagon, 2014; Sheridan, 2016). According to Sheridan, pedagogical beliefs include teacher beliefs about teaching, beliefs about learning, beliefs about learners, beliefs about the program and curriculum, and beliefs about the school context. These beliefs are sometimes referred to as instructional beliefs since they reflect teachers' knowledge of theories. Beliefs about teaching refer to aspects significant in teachers' practice, such as teachers' beliefs about their teaching approach, teaching strategies, and teaching materials used in the classroom (Fives & Buehl, 2016). For Jones and Leagon (2014), beliefs about teaching relate to teachers' beliefs about specific teaching theories, including teaching methods and the use of teaching resources. They further explained that teacher beliefs about learning involved beliefs about learning principles. Different teachers have different beliefs about the nature of how students learn science. Some teachers hold the constructivist view of learning and believe learning is a process of acquiring knowledge through encountering experiences (Jones & Leagon, 2014).

Other beliefs associated with science teaching and learning include epistemological beliefs, applicability beliefs, and science teaching efficacy beliefs (Pajares, 1992; Jones & Carter, 2007; Jones & Leagon, 2014; Sheridan, 2016). Although all beliefs are involved in science teaching and learning, some beliefs are more connected to classroom practices than others. For example, Friedrichsen et al. (2011) proposed that beliefs about effective science instruction (i.e., IBI) are core beliefs that impact classroom practice. Even though there are different models or types of teacher beliefs, there is an agreement that pedagogical beliefs are reported to dominate teacher classroom practice. This study wanted to establish novice teachers' beliefs about IBI. So the focus will be on teachers' pedagogical beliefs, teaching and learning beliefs, since beliefs about what teaching is and how it should be conducted are fundamental to reform movements in education, such as inquiry-based pedagogy.

2.2.5 Categories of teacher beliefs

As explained above, this study focuses on novice physical sciences teachers' teaching and learning beliefs about IBI. Research studies aimed at categorising these teaching and learning beliefs focused on the continuum from teacher-centred to learner-centred (Luft & Roehrig, 2007; Mansour, 2013). Teacher-centred beliefs support the transmission or traditional model of teaching (i.e., learners receive knowledge from the teacher). Learner-centred represents reformed beliefs (e.g., IBI) that learners construct knowledge when actively engaged in the educational process and assuming responsibility for their own learning (Luft & Roehrig, 2007; Mansour, 2013). Luft and Roehrig (2007) developed the Teacher Belief Interview (TBI) to capture belief change and used it to establish a taxonomy of belief orientations. Table 1.1 indicates Luft and Roehring's framework that measures beliefs along a continuum from teacher-centred to learner-centred.

Table 2.1

TBI framework

Category	Description
Traditional	Focus on information, transmission, structure, or sources
Instructive	Focus on providing experiences, teacher focus, or teacher decisions.
Transitional	Focus on teacher-student relationships, subjective decisions, or affective responses.
Responsive	Focus on collaboration, feedback, or knowledge development.
Reform-based	Focus on mediating student knowledge or interactions.

Note: This Source of the TBI framework was developed by Luft & Roehrig (2007, p. 54)

The teacher belief continuum includes five categories, as indicated in Table 2.1. Traditional and instructive represent teacher-centred beliefs, whereas responsive and reform-based are more learner-centred. The transitional has aspects of both teacher and learner-centred beliefs and is focused mostly on teacher or learner relationships. The TBI protocol's categorisation aligns with Savasci and Berlin's (2012) constructivist beliefs. Savasci and Berlin include five categories: traditional, instructive, transitional, responsive, and reform-based. Traditional and instructive represent teacher-centred beliefs. Responsive and reform-based are more learner-centred. The transitional orientation has both teacher and learner-centred views (i.e., wobbling beliefs) and focuses mainly on teacher/learner relationships. For instance, a traditional teacher views science as a rule of facts and does not have beliefs about how science is practical

Several studies have examined science teachers' teaching and learning beliefs, especially novice teachers. For example, Luft and colleagues (Fletcher & Luft, 2011; Wong& Luft, 2015; Luft & Zhang, 2014; Luft & Roehrig, 2007) have explored science teachers' teaching and learning beliefs. In the TBI study, Luft and Roehrig (2007) explore the development of beginning teachers involved in different induction programs. Their findings indicated that beginning secondary school teachers had beliefs at the instructive level, which tended to move toward traditional for those in general education programs and toward transitional for those in science-focused programs. Luft and Zhang (2014) conducted a study to determine if an induction program could change the beliefs and PCK of novice teachers. The data analysis revealed that even though beginning teachers' beliefs were impacted differently and by different factors, they were more influenced by their school cultures than their induction programs. Fletcher and Luft's (2011) study findings revealed similar factors that cause the shift in novice teachers' beliefs. Those factors included static school culture, little support from school leaders for implementing reform-based strategies, and the new teachers' feelings of being overwhelmed.

Mavhunga and Rollnick (2016) attested that teachers' programs influenced novice teachers teaching and learning beliefs. They conducted the TBI study to uncover the shifts in South African science teacher beliefs experienced when chemistry pre-service teachers are exposed to an intervention that targets the improvement of Topic-Specific Pedagogical Content Knowledge (TSPCK) in chemical equilibrium. Their observation revealed that the development of TSPCK appears to influence in a significant way a shift of science teacher beliefs associated with learner-centred classroom practices towards responsive and reformed kinds of beliefs. Similar findings from Wong (2016) examined 21 United States middle school science and mathematics teachers' beliefs over one year. The findings revealed that the science and mathematics teachers who participated in the first year of a two-year graduate online program that emphasised IBI significantly changed their beliefs. The participants moved toward holding more student-centred beliefs. It was also established that teacher beliefs were affected by personal experiences, prior knowledge, and formal education, including teacher education and professional development interventions.

The above studies reveal two similar patterns in connection with science teacher beliefs and are valuable for this study. Firstly, TBI is a valuable instrument to explore teachers' beliefs and the assumptions that teachers apply to their classroom practice. In this study, I opted to use Luft and Roehrig's (2007) belief framework to determine the nature of beliefs for novice physical sciences teachers. Secondly, the importance of novice teachers to be involved in developmental programs for learner-centred beliefs. The programs teachers participated in influenced their teaching and learning beliefs more than school factors that novice teachers encountered. Speer (2008) suggested a professional development program that focused on specific and meaningful aspects of practices, such as providing support for teachers' knowledge and sharing good practices through tasks and activities. Moreover, Luft and Zhang (2014) recommended that the programs focus on fortifying learner-oriented beliefs and knowledge, so that science instruction that supports student learning can be enacted.

2.3 Science teacher goals

Section 2.2 conceptualises the teacher beliefs, and in this section, I focused on sciences teachers' goals that they need to embrace in order to engage in IBI practices. Hutner and Markman (2017) suggested that one of the factors contributing to the lack of understanding between teacher beliefs and classroom practice is that previous research has paid little attention to teachers' goals in their pedagogical decisions. This study considers teachers' goals to understand this relationship.

2.3.1 Teacher goals: meaning

Like beliefs, the term goal takes on different meanings in different contexts. Using the framework from goal theory, Boersma et al. (2006, p. 928) introduced the term representation when defining goals as 'internal representations of desired states, where states are broadly construed as outcomes, events, or processes.' In addition to internal representations, Mansfield et al. (2012) consider three representations: internal representations of desired states, subjective representations of desired or undesired consequences, and cognitive representations of the desired endpoint that impact evaluations, emotions, and behaviours when defining goals. From those three representations, Pudelko and Boon (2014) chose cognitive and defined goals as cognitive representations of future events that motivate behaviour. However, Aguirre and Speer (2000) used the term constructs, not representations, to define goals as mental constructs that describe what a teacher wants to accomplish. Höchli et al.'s (2018) definition of goals is the same as Hutner and Markman's (2017) and Ruprich and Urhahne (2015) as mental representations of the desired end states that an individual has not yet (fully) achieved but aspires to in the future. In this study, I worked with Hutner and Markman's (2017) definition of goal as they argue that goals manifest when teachers account for their choices leading to classroom practice.

As with the operation between beliefs and knowledge, confusion exists between beliefs and goals. In literature, there is an overlap regarding using these terms for beliefs and goals. Some researchers treat teachers' beliefs and goals as separate mental constructs (Aguirre & Speer, 2000; Hutner & Markman, 2017; Schoenfeld, 2011). Some researchers treat teacher goals as overlapping mental constructs or subsets of teacher beliefs and knowledge (Kang, 2008; Kang & Wallace, 2005; Friedrichsen et al., 2011; Webel & Platt, 2015). Moreover, in the pedagogical content knowledge (PCK) models by Shulman (1986) and Magnusson et al. (1999), goals are conflated as components of PCK. While other researchers use the terms beliefs and goals interchangeably or treat them as overlapping mental constructs, some researchers make the distinction between teacher beliefs and goals. For example, Aguirre and Speer (2000) and Schoenfeld (2011) have made a distinction between these mental constructs and argued that beliefs tend to guide our goals, emotions, decisions, actions, and reactions. They consider beliefs and goals as separate mental constructs but equal interplay in teacher cognition. Aguirre and Speer (2000) gave details of how teacher beliefs inform practice, particularly in formulating goals in the classroom. According to Aguirre and Speer, the belief bundles played a central role in formulating goals that influence teachers' actions during classroom practice. Moreover, Schoenfeld (2011) prioritised beliefs and values over goals as he points out that beliefs shape teachers' goals for classroom interaction.

In the context of this study, I opted for Hutner and Markman's (2017) definition of treating goals as their own mental construct separate from teacher beliefs. Similarly, Aguirre and Speer (2000) argued for the distinction between goals and beliefs. They gave details on how beliefs inform classroom practice by playing a central role in teachers' selection and prioritization of goals in their teaching. Moreover, Aguirre and Speer added that beliefs shape how teachers perceive and interpret classroom interaction which influences their responses and decision-making processes in the classroom. Beliefs are related to the reasons people pursue goals. For example, when goal pursuit is based on appearance belief, that person will focus on a goal to look good. The distinction of teacher goals from teacher beliefs has an important implication for this study as I explore the role of each construct in teachers' classroom practice. Therefore, I sought to identify teachers' instructional goals as a window into their IBI practices for this study.

2.3.2 Goal hierarchy approach

One of the most fundamental characteristics of a goal is its level of abstraction in the hierarchy. The hierarchical organisation at the level of abstraction is based on how teachers hold their goals. Some goals are fundamental, and others are related to or derived from them. For example, consider the goals of teaching science through IBI, developing high-order thinking skills, and developing laboratory skills in a lesson. These goals are related to inquiry teaching and learning but differ in their hierarchical organisation. The goal of developing laboratory skills carries a one-to-one relationship with the action required to achieve it. At the same time, using IBI requires multiple actions at different points to be taken to achieve it. Researchers have classified goals through goal hierarchy with the level of abstraction.

Boersma et al. (2006), Hutner (2015), Hochlie et al. (2018), and Schoenfeld (2011) use a hierarchical model with three levels to classify goals. At the highest level of the hierarchy are higher-order goals, which are more abstract, broad in both scopes, and require multiple actions to be achieved. Higher-order goals, also called superordinate or overarching, are at the most abstract level of the goal hierarchy. The intermediate, mid-level, or major instructional goals are in the middle. They mediate between superordinate and subordinate goals. Lastly, the lowest level is subordinate, local, or specific goals. These are concrete goals typically quite specific in both scope and actions. According to Hochlie et al. (2018), the subordinate goals[3] define precisely what to do and how to do it, and they specify concretely how goals one step up in the hierarchy, i.e., intermediate goals, can be achieved. They also take into account the environmental affordances and constraints in achieving the intermediate goals. The intermediate goals help achieve superordinate goals. Hochlie et al. (2018) refer to superordinate[4] goals as goals that reflect what is important or not important to a person. Within the context of teaching, pedagogical approaches such as IBI are often framed as overarching goals (Hutner & Markman, 2017). IBI is considered an overarching goal because it can only be realised in classroom practice via more specific goals.

2.3.3 Nature of goals

Teachers hold multiple goals in their goal system that can reinforce, compete, or conflict, just as beliefs in a system. Goals in a system can be reinforcing such that efforts to achieve one

[3] I refer to subordinate goals as specific goals in this study.

[4] I refer to superordinate goals as overacrching goals in this study

goal also help achieve a second goal, or they can be conflicting, such that efforts to achieve one goal hamper efforts to achieve a second goal (Hutner et al., 2021). Goal competition exists in situations where both goals are desirable, yet only one goal can be pursued at a time, whereas goal conflict, on the other hand, exists when progress toward one goal leads to movement away from another goal (Hochlie et al., 2018; Hutner, 2015; Hutner et al., 2019). According to Kelly et al. (2015), goal conflict is when the pursuit of one goal undermines or precludes the successful pursuit of another. For example, when a teacher has simultaneous goals, to work long hours to get ahead in his or her career, but also wants to spend lots of time with his or her family and friends. These goals are mutually exclusive; in this case, a teacher must move away from one goal. Hutner et al. (2019) suggested that goal conflict may contribute to the inconsistency between teachers' self-reporting and their observed classroom practice. However, Hochlie et al. (2018) recommended that goal conflict be resolved productively by prioritising one goal.

Some teachers have difficulty setting teaching goals related to measurable outcomes and focus on teaching practices without considering the purpose of their teaching. One cannot overemphasise the importance of novice physical sciences teachers setting appropriate goals for supporting the holistic development of learners. The understanding of setting these goals proceeds from teachers' knowledge of teaching and the curriculum. According to Camp (2017), goal setting can benefit teachers by spurring them to directed action or triggering thinking that leads to self-understanding and controlling feelings. The analysis of Camp's study also sheds light on how strong self-efficacy, one of the potential factors that helps and hinders goal achievement, assists teachers in staying committed to their goals. Camp, however, suggested that factors such as insufficient knowledge about the goal-setting process, experience in formulating the goals, and lack of time complicate the process of establishing teaching goals for teachers.

2.3.4 Science teacher orientations and goals

Science teaching orientations also called pedagogical orientation, are teachers' knowledge and beliefs about the goals and purposes of teaching science (Friedrichsen et al., 2011). Kind (2016) considered science teacher orientation a central component of PCK, which helps direct teachers' teaching. Magnusson et al. (1999) introduced nine different orientations, i.e., didactic, process, academic rigor, conceptual change, activity-driven, discovery, project-based science, inquiry, and guided inquiry, in their model of PCK. They further linked science teaching orientations to the goals of teaching. Several different research studies have used Magnusson et al.'s orientations to understand the translation of their influence on science teachers' classroom practice. However, Friedrichsen et al. (2011) argued that some of these orientations might overlap with each other. Kind (2016) deliberates Friedrichsen et al.'s argument, and from her study, she explored orientations held by pre-service science teachers and confirmed five teacher orientations. From the understanding that orientations can be complex and messy, Cobern et al. (2014) identified four orientations used to develop a case-based assessment called the Pedagogy of Science Teaching Test (POSTT). Their orientations, i.e., didactic and active direct, guided, and open inquiry, can be regarded as a spectrum from teacher-centred to learner-centred instruction. In this study, I used the POSTT to establish how novice physical sciences teachers desire to teach physical sciences.

This study contemplated the argument by Friedrichsen and Dana (2005) and referred to science teaching orientation as teachers' overarching goals, different from teachers' beliefs. Friedrichsen and Dana (2005) argued that science teaching orientations might be represented by 'central' and 'peripheral' components of teaching goals. Recently, Friedrichsen et al. (2011) noted that the definition of teaching orientations is still blurred since multiple explanations have been given for the same concept. While some scholars explain teaching orientations as 'the goals and purposes of science teaching,' other scholars have explained the orientations as 'a general way of viewing teaching science.' Friedrichsen and Dana's (2005) study to examine the nature and sources of science teaching orientations held by four secondary biology teachers suggested that additional research was needed to understand better teachers' goals and purposes for teaching science subject matter. In this study, I considered science teaching orientations overarching goals based on Friedrichsen and Dana's (2005) and Friedrichsen et al.'s (2011) arguments.

Furthermore, orientations influence teachers' practice by serving as a conceptual map that guides instructional decisions during planning and teaching, which ensemble the role of goals in teacher cognition. I also refer to orientations as overarching goals using the description for each science teacher orientation to which Magnusson and colleagues subscribed. Henceforth, in this study, I regard these four orientations, i.e., didactic and active direct, guided, and open inquiry, as overarching goals. For example, I described novice physical sciences teachers as having guided inquiry or active direct goals. Table 2.2 presents the four orientations and pedagogical approaches by Cobern et al. (2014). The Table also includes goals of teaching science as explained by Magnusson et al. (1999) from teacher orientations.

Table 2.2

Orientations with pedagogical approaches and goals of teaching science

Teaching Orientations	Characteristic of instruction	Teaching goal
Didactic Direct	The teacher presents and explains the science concept or principle directly to learners and illustrates it with examples and/or demonstrations. Learners apply this knowledge to questions and problems. There are no or few learner practical activities in this method, but there are usually discussions and problems on the content.	Transmit the facts of science
Active Direct	It entails direct teacher exposition, but this is followed by a learner activity based on the presented science content, for example, hands-on practical verification of a law.	Have students be active with materials; "hands-on" experiences.
Guided Inquiry	The teacher plans an activity where learners explore a phenomenon or idea, and from this, the teacher guides them to develop the desired science concept or principle.	Constitute a community of learners whose members share responsibility for understanding the physical world, particularly with respect to using science tools.
Open Inquiry	Learners explore a phenomenon or idea on their own, devising ways of doing so, minimally guided, after which they report what they did and found. The teacher facilitates the student activity but does not intervene more than necessary. The emphasis is on the inquiry process.	Represent science as an inquiry

According to the explanation in Table 2.2, a science teacher with a didactic direct orientation has a teaching goal of transmitting facts. The classroom practice for the teacher is also explained under the characteristics of instruction. The instructional characteristics in this Table are comparable to the teaching and learning beliefs described in Table 2.1. For example, I regard teachers with didactic and active direct orientations as having teacher-focused goals.

The guided and open inquiry orientations are regarded as learner-focused goals. Even though active direct is teacher-focused, it differs slightly from didactic direct because learners engage in hands-on practical activities.

Several studies have been conducted to examine the relationship between science teachers' teaching orientations and classroom practice. Ramnarain and Schuster's (2014) study investigated the orientations of in-service grade 12 physical sciences teachers from different school contexts (i.e., disadvantaged township and more privileged suburban schools) using POSTT. The findings revealed remarkable differences between teachers' orientations at disadvantaged township schools and teachers at more privileged suburban schools. Teachers at township schools had a strong, active direct orientation, while suburban school teachers exhibited a guided inquiry orientation. These findings suggest that the context in which teachers work can influence their goals. Sondlo and Ramnarain's (2018, 2021) studies also showed that environmental factors, such as the number of learners, time constraints, availability of resources, and curriculum goals, also impact science teachers' orientations. Similar findings were found in the comparative study between SA and Malawi (i.e., African countries) conducted by Ramnarain et al. (2016). Moreover, their findings revealed that inquiry-based orientations facilitated during science teacher education programs could be influenced by the contexts in which science teachers work.

Ladachart (2019) examined 19 first-year pre-service teachers' science teaching orientations and whether they correlate with an understanding of the nature of science using the adapted versions of POSTT in Thailand. Analysis of the data collected revealed that, on average, the participants tended to have orientations between active direct and guided inquiry. Ladachart's assumption from the results was that beginning pre-service teachers' orientations were influenced by their prior schooling experiences. Furthermore, Thilaworrakan and Ladachart (2021), in their study, indicate that from POSTT, science teachers' orientations were between active direct and guided inquiry. However, during the interviews, most teachers used didactic teaching models. These results reflect the inconsistency between orientations and practice. Moreover, indicate the reality of teaching and the challenges of the educational crisis in the 21st century.

The above studies explored or investigated science teachers' orientations using POSTT and have focused on classroom enactment and factors that influence it. These studies suggested that most science teachers tend to have orientations between active direct and guided inquiry. They have also established that contextual factors influence science teachers' orientations. Similarly, Henze and van Driel (2015) reported situational factors, such as lack of time and other professional responsibilities, may have been responsible for remarkable differences between teacher-articulated orientations and actual classroom behaviours observed during science lessons. However, none of these studies have explored why teachers have these orientations or their role during classroom practice. This study seeks to add to the knowledge base by explaining how novice physical sciences teachers' overarching goals influence their IBI practices. I opted to use POSTT to explore the overarching goals of novice physical sciences teachers.

2.4 IBI classroom practices

IBI is a desirable teaching practice that provides a more fruitful context for learners to learn how science knowledge develops, parallels how scientists do science, and makes cognitive demands on learners that traditional instruction rarely does (Ward, 2016). Sciences teachers present a wide range of beliefs and goals about IBI, making it important for this study to articulate the specific context for inquiry to understanding its premise. Since the purpose of this study is to understand the relationship between novice physical sciences teachers' beliefs and goals about IBI to their classroom practice, it is important to describe core classroom practices associated with IBI. It is important to note that this study is not praising any level of inquiry, but the focus is on the relationship between teachers' beliefs and goals about IBI to their classroom practice. Choosing an IBI at any level should assume a teaching goal targeting the specific lesson objective or outcomes.

IBI considered in this study includes inquiry with a problematic and non-problematic character serving a different purpose in science learning and teaching. I used the Electronic Quality of Inquiry Protocol (EQUIP) to understand the quality of IBI during classroom practice for novice teachers (Marshall et al., 2010). Table 2.1 indicates the order of instruction to the type of inquiry (i.e., teacher classroom actions at different levels of inquiry) from the instrument.

Table 2.3

Levels of IBI

Level of inquiry	Type of inquiry	Order of Instruction
Level 1	*Pre-inquiry*	Teacher-centred, passive students, prescriptive, didactic discourse pattern, no inquiry attempted
Level 2	*Developing inquiry*	Teacher-centred with some active engagement of students, prescriptive though not entirely, mostly didactic with some open-ended discussions, teacher dominates then explains, teacher seen as both giver of knowledge and as a facilitator, beginning of class warm-ups
Level 3	*Proficient inquiry*	Largely student-centred, focus on students as active learners, inquiries are guided and include student input, discourse includes discussions that emphasize process as much as product, the teacher facilitates learning, and students are active in all stages, including the explain phase
Level 4	*Exemplary inquiry*	Student-centred, students active in constructing an understanding of content, rich teacher-student and student-student dialogue, the teacher facilitates learning in effective ways to encourage student learning and conceptual development, assumptions and misconceptions are challenged by students and teacher

Marshall et al. (2010) classified the level of inquiry as pre-inquiry (level 1), developing (level 2), proficient (level 3), and exemplary (level 4) inquiry. The levels or types of inquiry directly relate to the amount of structure provided by the teacher. The classroom practice of pre-inquiry indicates that the teacher is not familiar with IBI, and no inquiry is attempted. Developing inquiry performance indicates that the teacher is familiar with getting learners engaged even though learners are engaged in a more prescriptive manner which is teacher-centred. Proficient inquiry teacher's classroom practice demonstrates a learner-centred inquiry that actively engages learners. Exemplary inquiry is the highest, which teachers generally do not demonstrate because of its high quality of IBI.

Several inquiry models have been proposed to support understanding the characteristics of IBI. 7E, 6E, 5E, 4E, and 3E model (Bybee, 2009., 2015). The 'E's denote Elicit, Engage, Explore, Explain, Elaborate, Evaluate, and Extend and vary depending on the number of E's in the model. Even though these models may subtly differ in naming and the number of steps, they are similar in that they accentuate what needs to occur during inquiry instruction. These IBI models place importance on developing high-order thinking skills, deep conceptual knowledge over the surface, and rote learning.

As mentioned in chapter one, IBI practices were reported to be challenging in most science classrooms. For example, Capps and Crawford (2013) studied the understandings of inquiry held by 26 fifth- through ninth-grade teachers. Their findings revealed that teachers have an inadequate understanding of inquiry. There was little evidence of inquiry, even in highly motivated, well-qualified science teachers. The teachers generally equated inquiry with hands-on work and discovery learning. Although science teachers mentioned that they enjoy IBI, their practices will not be aligned with their goals. For example, Engeln et al. (2013), in their survey of the current status of inquiry-based learning, revealed that across Europe, only 8 % of science and mathematics teachers regularly use inquiry-based while 51% were still highly teacher-centred. Similarly, Feyzioglu (2015) found that many pre-service teachers believe that they cannot successfully implement an inquiry-based approach in the classroom because they do not understand inquiry-based methods adequately. According to Capps and Crawford (2013), Engeln et al. (2013), and Feyzioglu (2015) studies, the poor implementation of IBI is credited to inadequate understanding and beliefs about the inquiry.

Saad and Boujaoude's (2012) study results indicate the barriers impeding inquiry teaching in science classrooms. They investigated the relationships between teachers' attitudes toward science, knowledge, and beliefs about inquiry and science classroom teaching practices. Their findings revealed that most science teachers had limited views of the nature of science and unfavorable beliefs and attitudes about inquiry. The lack of equipment and laboratory safety issues influence the inquiry implementation. They also included preparing learners for standardised tests and official exams and finishing mandated curriculum content within a set time limit. Ramnarain (2016) conducted the study using mixed-methods research to investigate teachers' perceptions of intrinsic and extrinsic factors influencing the implementation of inquiry-based science learning at township schools in South Africa. The findings highlighted a lack of professional science knowledge contributing to teachers' uncertainty in inquiry-based teaching. Also, extrinsic factors such as school ethos, professional support, resource adequacy, and time are significant constraints in implementing inquiry-based education at the school. Similarly, Tsakeni (2018) used a social, cognitive, and social justice lens to investigate teachers' implementation of inquiry-based learning in the South African schooling system. The results indicated that teachers undervalue inquiry-based practical work because of the absence of practical examinations from the assessment system. Additionally, instructional leadership practices did not support using this instructional strategy.

Research studies indicate that science teachers at different grade levels vary in their observed teaching practices, as indicated by the EQUIP ratings. The poor IBI practices are caused by a lack of understanding of inquiry practice and contextual factors. Even though studies indicate the above, there is a gap in what is known about IBI, why teachers decide to use different inquiry levels, and how they enact it in their classrooms. This study aimed to fill the gap on why science teachers use different inquiry levels during classroom practice.

2.5 The relationship between teachers' beliefs, goals, and IBI practices

There is still a discrepancy between teacher beliefs and science instruction. The science education researchers had not yet fully delineated the reasons for alignment or nonalignment between teacher beliefs and practice. Mansour (2013) opined that this relationship between teachers' beliefs and their in-reality teaching practices is still open for debate. However, Hutner and Markman (2017) suggested including teachers' goals to understand this relationship. So far, in sections 2.3 to 2.4, I have discussed the literature on the definition and nature of science teachers' beliefs, goals, and IBI practices. This section reviews the substantial literature in sciences education that has established the relationship between teacher beliefs and goals to their classroom practice. In the section below, I present studies exploring the relationship between beliefs about IBI to classroom practice. Secondly, the discussion is drawn from the literature goals and classroom practice. Lastly, I look at the studies exploring the relationship of beliefs and goals to classroom practices.

2.5.1 The (in)consistency of teachers' beliefs and IBI practices

According to Bryan (2012), the relationship between teachers' beliefs and classroom practices has two conflicting perspectives, congruent and incongruent. The congruent (i.e., consistency) perspective supports the assertion that the teachers' beliefs align with classroom practice. The incongruent (i.e., inconsistency) perspective demonstrates the nonalignment between teachers' beliefs and classroom practice.

Consistency studies: Mansour (2013) examined the extent to which ten science teachers' beliefs correspond to their practices in different schools in Egypt using the case study design.

Mansour's findings indicated that six science teachers had traditional and one mixed beliefs. Few in-service science teachers' pedagogical beliefs aligned with constructivist philosophy. Furthermore, teachers with traditional beliefs have a high consistency with teaching using traditional practices, and teachers with mixed beliefs (traditional–constructivist) have traditional practices. According to Mansour (2013), real-life factors such as learner behaviours, time, resources, and course content impact the degree of belief–practice consistency. Hong and Vargas (2015) explored how early-career science teachers perceive and interpret the calls for IBI in relation to their emerging professional identity and beliefs. They interviewed twelve early-career science teachers. The findings revealed that teachers often showed limited understanding of IBI, such as hands-on lab activities, and devoted small amounts of time to implementing inquiry teaching. They also suggested that inconsistency between beliefs and practices results from contextual factors such as lack of time to plan and implement inquiry teaching, learners' low cognitive abilities, lack of effort, and disruptive behaviours.

Similarly, Ozel and Luft (2013) investigated the conceptions and use of inquiry during classroom instruction among 44 beginning secondary science teachers from five different states in the United States. The findings indicated the consistency between how new teachers talked about inquiry and how they practiced it in their classrooms. However, the beginning secondary science teachers tended to enact teacher-centred forms with some elements of inquiry. They did not discuss or enact inquiry lessons in which the students focused on building arguments or sharing their new knowledge. They have limited conceptualisation and enactment of inquiry.

The above studies highlight essential findings of the alignment in teacher beliefs and IBI practices. Even though the studies revealed consistency between novice teachers' beliefs and classroom practice, these were mainly teacher-centred. Teachers hold teacher-centred beliefs and exhibit teacher-centred classroom practice. Hong and Vargas (2015) and Ozel and Luft (2013) attributed this observation to novice teachers' limited understanding of inquiry, resulting in a low level of inquiry implementation. Moreover, Mansour (2013) credited this degree of belief–practice consistency to contextual factors.

Inconsistency studies: Savasci and Berlin's (2012) study reported inconsistency between articulated teachers' beliefs and classroom practice. Savasci and Berlin examine science teacher beliefs and classroom practice related to constructivism and factors influencing classroom practice. Their cross-case study was with four science teachers from two schools.

Findings revealed that science teachers embraced constructivism beliefs, but it was frequently observed less practice than teachers believed they were using it. They identified school type, grade, student ability, standardised testing, and parental involvement factors influencing classroom practice. Capps et al. (2016) express similar findings from their study that the rate at which science teachers report enacting inquiry was significantly higher than their actual knowledge of inquiry within the classroom. The results indicate a disconnect between what science teachers said they were doing in the classroom and what was actually occurring. Beliefs alone were found not to be a good indicator of reformed-based science and teaching. The inconsistencies observed in these studies were attributed to contextual factors. Lebak (2015) expressed similar findings when examining the relationship between beliefs, practice, and change related to inquiry-based instruction of one science teacher teaching in a high-poverty urban school.

Within the SA context, Ramnarain and Hlatswayo (2018) conducted a study on grade 10 physical sciences teachers' beliefs and attitudes about inquiry-based learning in a rural school in Mpumalanga. Their findings revealed that sampled teachers had a positive attitude towards inquiry in the teaching and learning of physical sciences and recognised the benefits of inquiry, such as addressing learner motivation and supporting learners in understanding abstract science concepts. However, despite this positive attitude toward inquiry-based learning, teachers were less inclined to enact it in their lessons because of their limited knowledge. Moreover, the study identified contextual factors such as the prescriptiveness of the curriculum, content-based examinations, flexibility of the timetable, availability of resources, and class size as influencing teachers' instructional practices. The findings espoused here are similar to that of Mokiwa (2014), who explored the teaching of physical sciences through inquiry with four participants in South African schools using observation protocol and individual interviews. Analysis of results showed that these teachers held relatively limited views (i.e., knowledge and beliefs) of inquiry, using teacher-centered approaches. Even experienced teachers struggle to enact inquiry-based teaching, and therefore he recommends professional development programs that will enrich teachers' inquiry knowledge.

Mokiwa's (2014) recommendation of a professional development programme was supported in the study conducted by Dudu (2014). He explored the experiences of 37 physical science high school teachers who participated in a professional development program. The purpose of the study was to evaluate the effectiveness and value of the Experiment 10+ kits. The findings suggest that science teachers approaches shifted from the traditional approaches of science teaching to the implementation of inquiry-based teaching after attending the program. However, Bartos and Lederman (2014) were not in agreement. They found that even though the teachers had received instruction on NOS and scientific inquiry from the researchers in the project and were aware of the study's intent, their sophisticated views were not manifested in practice.

Caleon et al. (2018) raised the issues of teaching experience in the mismatch of beliefs and practice. They examined the beliefs about teaching and learning physics and instructional practices by comparing five beginning teachers and seven experienced teachers from Singapore. The findings revealed that the beginning and experienced teachers differed in their beliefs about teaching, learning, and instructional practices. The experienced teachers tended to have beliefs about teaching and learning physics closer to constructivist views, whereas beginning teachers generally espoused transmission beliefs. Although both groups' classroom lessons were largely teacher-dominated, more elements of constructivist instruction were found in the classroom lessons of the experienced teachers.

The findings from these studies have yielded mixed results, the consistency and inconsistency between science teachers' beliefs to their classroom practice. Research studies acknowledged that this relationship remains poorly understood (Jones & Leagon, 2014). The above studies show numerous contextual factors contribute to this mismatch between beliefs about IBI and science teachers' classroom practices. These factors may support or interfere with the role of teacher beliefs in their classroom practice. According to Buehl and Beck (2015), these factors can be classified into three levels which are embedded within one another. The first level represented the classroom, the next level represented the school, and the last represented national, state and district. Moreover, pressures at one level may be present or have an impact at another level.

However, these studies provide inadequate explanations, mainly when teachers exhibit beliefs not reflected in their teaching. The mismatch in beliefs and practice is credited to contextual factors and a lack of inquiry understanding. However, there is no clear explanation of how these factors influence teachers' knowledge and belief system about IBI to their classroom practice. Moreover, these studies did not discuss the function of teacher goals in classroom practice. As for that, this study will explore the influence of affordances and constraints on teacher cognition.

2.5.2 The (in)consistency of teachers' goals and IBI practices

While the above research studies indicate that teacher classroom practice can be explained and understood as the function of teacher beliefs, the studies discussed below suggest that classroom practice can also be understood in terms of teaching goals. Therefore, teacher goal orientations have been mainly explored in relation to teachers' instructional practice (Butler, 2012; Butler & Shibaz, 2014; Retelsdorf et al., 2010; Retelsdorf & Gunther, 2011). According to Mansfield et al. (2012), goals reflect behaviour and influence cognition towards intermediate tasks and long-term desires. Goals influence how individuals organise processes of thinking, behaving, and emotional responses in everyday situations, i.e., future outcomes and actions.

Researchers suggest that teacher goals are an important influence on teaching (Aguirre & Speer, 2000; Angelo & Cross, 1993; Bol & Strage, 1996). One of Nespor's (1985) thesis assumptions, the Teacher Beliefs Study (TBS), was premised on teachers acting in a goal-directed fashion. And to understand why teachers act in a certain manner, one must examine their goals and the ways these goals are articulated with work contexts and the tasks within those contexts. Consistent with these findings is Friedrichsen and Dana's (2005) that the secondary biology teachers they studied held multiple goals for their learners that varied for different classes and levels. Central goals dominated teachers' thinking, appeared to drive decision-making, and were highly visible in practice, whereas peripheral goals had less influence than central goals.

Several studies indicated the relationship between teachers' practices at odds with their expressed goals. For instance, Bol and Strage (1996) point out that teachers may verbalize their commitment to fostering critical thinking, problem-solving, analytical skills, and other higher-order thinking skills with their learners. Still, there may not be a close alignment between stated instructional goals and learners' engagement in these skills. For example, science teachers who see their roles as guides or facilitators have goals of helping their learners integrate what they learn in the science classroom into their daily lives. They also prepare learners for a life in a world of rapid scientific and technological change making the content inquiry-based. Even though science teachers advocate higher-order cognitive skills through IBI, there is a mismatch between these stated goals and actual classroom practices.

Marshall and Horton (2011) worked with science and mathematics teachers and conducted 100 classroom observations to assess the attributes of the 4Es (i.e., Engage, Explore, Explain, Extend) model for IBI. The implications of their study indicate that if teachers have an instructional goal to develop reasoning and critical thinking, they must provide opportunities for learners through the exploration to develop ideas for themselves. Moreover, when the goal is to help learners achieve a deep understanding of concepts, teachers may be advised not only to provide time for exploration before the concepts are explained but also to ensure that the time allowed for this exploration is sufficient, even if it replaces time that may have been planned for an explanation. These findings apply to this study to suggest science teachers' goals for IBI.

Sizer et al. (2021) investigated how pre-service elementary teachers' orientation about science inquiry impacts their implementation of inquiry-based instruction. They collected data from thirty-one pre-service teachers using a survey and three vignettes. The results revealed three significant findings. Firstly, there was a moderate relationship between pre-service teachers' views of inquiry-based instruction and their willingness to implement it. Secondly, the pre-service teachers' confidence in implementing inquiry-based instruction increases as they gain experience with inquiry-based methods through coursework. Lastly, the participants favour using inquiry methods but feel more comfortable with a more teacher-centred approach. The findings implied that one science method course might not suffice to produce self-efficacious teachers in teaching inquiry-based science. Moreover, teachers may desire to use inquiry but not engage with it during classroom practice.

The above studies document the teaching goals science teachers hold and their relationship to instruction. Owing to the inconsistency of the links between teachers' goal orientations for teaching and their teaching practices, Retelsdorf and Gunther (2011) opined that 'the degree to which teachers promote students' comprehensive learning rather than surface learning might be taken as an indicator for instructional quality (p. 112)'. They proposed a model indicating the sequential relations between teacher goal orientations, reference norms (evaluation of certain outcomes), and instructional practice.

2.5.3 Influence of teacher beliefs and goals on classroom practices

The inconsistencies of the above studies indicate that beliefs alone are not a good indicator of reformed-based science and teaching, such as IBI. While some studies have found contradictions between teacher articulated beliefs and actual practice, other studies have found that teacher espoused beliefs are consistent with enacted classroom practice. To understand teacher actions in the classroom, some researchers suggested that the disparity between teacher knowledge and beliefs to their classroom practice could be attributed to the goals a teacher holds (Aguirre & Speer, 2000; Hutner & Markman, 2015, 2016 & 2017; Kang & Wallace, 2005; Webel & Platt, 2015). This section reviews some studies between teacher beliefs and goals

In their study, Kang and Wallace (2005) explored how three experienced science teachers' epistemological beliefs and teaching goals relate to their laboratory activities. Their findings revealed that teachers' naive epistemological beliefs are reflected in their teaching practices but are not always clearly connected to the teacher's classroom practice. Also, they indicated that teachers' primary teaching goals influenced their ways of using laboratory activities during science instruction. For example, when one of the teachers in their study intended to help learners pass a state-mandated test, the teacher used a structured laboratory to help learners remember factual knowledge. The same teacher used a problem-solving type laboratory to engage students in scientific inquiry and construct their own knowledge. Kang and Wallace's findings imply that science teachers may have sophisticated beliefs but do not always apply them to their teaching practices. They suggested that understanding teachers' actions through their instructional goals can also serve as a critical window into teachers' beliefs and what epistemological perspectives are conveyed to students in the classroom.

Kang (2008) studied 23 pre-service science teachers from a science methods course by analysing their learning histories, classroom observations, lesson plans, video recordings of teaching, and reflections on their practices. In this study, teachers' goals were categorised into two: developing scientific thinking skills (e.g., analytical thinking, curiosity, logical thinking) and appreciating scientific knowledge (e.g., applying scientific knowledge to everyday situations). The findings revealed that teachers' personal epistemologies and teaching goals were congruent. Pre-service teachers with sophisticated epistemologies espoused teaching goals consistent with the current science education reform. For example, teachers who defined science as evolving theories and processes of multiple methods to answer scientific questions, aimed to encourage critical thinking in learners, allowing them to participate in group discussions and share their ideas. On the other hand, teachers who defined science as a body of knowledge as received facts or as received inquiry addressing the work of scientists, failed to enhance learners' critical thinking. Instead, they aimed to develop an appreciation for scientific knowledge by integrating real-life scientific concept applications. Kang's (2008) study suggested identifying teachers' epistemological beliefs and goals as sources for shaping teaching practice.

Kind (2016) explored the extent to which science teachers' beliefs aligned with their science teaching orientations. Data collected from 237 pre-service sciences teachers prove that teachers with informed beliefs were 14.3%, partially informed, 38.4%, and naïve, 43.5%. These science graduates hold mainly naive and partially informed beliefs about science, and few hold informed beliefs. The connections between science teaching orientations and epistemological beliefs were mixed. Science teaching orientations vary according to teachers' experiences and expertise, so they will not remain constant throughout a career. These results provided evidence that teacher orientations override their beliefs. Lopes and Santos (2013) conducted a research study with primary teachers to explore the relation of teachers' classroom management beliefs to teachers' classroom goals and practices. Three distinct teaching beliefs profiles: teacher-centred, student-centred, and ambivalent/inconsistent, were identified from the analysis. The study's findings suggest that teacher-centred and student-centred participants set goals and report classroom practices consistent with their personal beliefs about classroom management.

Similarly, Groth's (2010) research study describes how goals, knowledge, and beliefs influenced the decisions made in framing the metaphor of student teachers. The study's findings indicate that beliefs and knowledge about the use of qualitative studies fed into the goals of producing a thick description of participants' thinking. Also, Aguirre and Speer (2000) found that teachers' instructional goals mediated the enactment of particular beliefs through classroom instruction in their study of mathematics teachers' goals. Hannah et al. (2014) examine the pedagogical practice of university mathematics lecturers in a course in linear algebra. They use Schoenfeld's framework describing the relationship of resources, orientations, and goals (ROG) to decision-making to analyse the lecturer's practice. The lecturer's overarching goal of assisting students in seeing the big picture and the methods he employed were linked to his orientations (beliefs) and drew on many resources (knowledge) to achieve these goals.

The findings from the above studies confirm that teachers' beliefs and goals affect their instructional practices. Although these studies provide an understanding of the effect of these constructs on their IBI instructions, one limitation should be noted. The above studies illustrate the alignment or non-alignment between beliefs and goals to classroom practice, but there is no clear explanation of how beliefs and goals interact to produce classroom actions. One of the reasons may be that some of these studies treat beliefs and goals as the same constructs (Kang, 2008; Kang & Wallace, 2005). Moreover, the above studies do not provide explanations of how beliefs and goals relate to their classroom practice. This research study aims to help fill this gap. The stance taken by this study is that in understanding how beliefs and goals relate to classroom practice, it is vital to seek an understanding of each of these critical cognitive processes, i.e., beliefs and goals, not in isolation but more holistically. If the ultimate purpose of research on teaching is to shape, direct, or improve teachers' practices, then teachers' reasons for acting as they do, which make them more or less amenable to advice and training, must be explored.

2.6 The alignment between teachers' beliefs, goals, and IBI practices

Emerging from the literature review is understanding the characteristics of teachers' beliefs and goals and their instructional practices. I, therefore, used these characteristics as the conceptual framework to understand the alignment between different levels of teachers' beliefs, goals, and IBI practices. Table 2.4 illustrates the alignment as each category has been discussed above.

Table 2.4

Alignment between teachers' beliefs, goals, and IBI practices

BELIEFS TBI LUFT & ROERIGH (2007)	OVERARCHING GOALS POSTT CORBEN et al. (2014)	GOAL OF TEACHING SCIENCE MAGNUSSON et al. (1999)	CLASSROOM PRACTICE EQUIP Marshall et al. (2010)	CLASSROOM PRACTICE DESCRIPTIONS Marshall et al. (2010)
Traditional	Didactic direct	Transmit the facts of science	Pre-inquiry	There is no inquiry attempted, teacher-centred, passive learners, prescriptive, didactic discourse pattern.
Instructive	Active direct	Have students be active with materials; 'hands-on' experiences.	Developing inquiry	Teacher-centred with some active engagement of learners, prescriptive though not entirely, mostly didactic with some open-ended discussions,

Transitional				teacher dominates the explain phase, teacher seen as both giver of knowledge and as a facilitator, beginning of class warm-ups.
Responsive	Guided Inquiry	Constitute a community of learners whose members share responsibility for understanding the physical world, particularly with respect to using science tools.	Proficient inquiry	Largely learner-centred, focus on learners as active learners, inquiries are guided. They include learner input, and discourse includes discussions that emphasize process as much as product, the teacher facilitates learning, and learners are active in all stages, including the explain phase.
Reform-based	Open (Authentic) Inquiry	Represent science as an inquiry	Exemplary inquiry	Learner-centred, learners are active in constructing an understanding of content, rich teacher-learner, and learner-learner dialogue. The teacher facilitates learning in effective ways to encourage learner learning and conceptual development. Learners challenge assumptions and misconceptions.

As discussed above in sections 2.2.5, 2.3.4, and 2.4, in theory, Table 2.4 explains the perspective of the alignment between beliefs, goals, and IBI. For example, the assumption is that a teacher who holds traditional beliefs will pursue a didactic direct goal and have level one, i.e., pre-inquiry practices. The alignment in the example indicates a direct relationship between these mental constructs. An example that will indicate nonalignment is a teacher who holds responsive beliefs with an active direct goal and developing inquiry practices. This example illustrates an indirect relationship between teacher beliefs and goals.

2.7 The chapter summary

In this chapter, I discussed the meanings of knowledge, beliefs, and goals and the relationship between these constructs to classroom practice. Having been informed by the research questions, firstly, I reviewed literature that conceptualised the meanings of knowledge, beliefs, and goals. I focused on their meanings and the context in which they are used in the studies. The review indicated that they are used differently and sometimes considered the same, different, or subsumed in each other. It was important for me to clarify how these mental constructs will be used in this study since there is confusion about their operation. Secondly, I reviewed the literature between teachers' beliefs, goals, and classroom practice. I looked at the literature between beliefs and practice, then goals and practice. The review confirms that beliefs and goals impact teachers' classroom practice. Lastly, I reviewed the literature that combined both beliefs and goals to classroom practice. The review suggests an equal interplay between teachers' beliefs, goals, and classroom practice.

The next chapter presents the theories that framed the study and guided the data analysis.

CHAPTER THREE
THEORETICAL FRAMEWORK

3.1. Introduction

This study explored the relationship between novice physical sciences teachers' beliefs and goals to IBI practice. The previous chapter reviewed the literature on science teachers' beliefs, goals, and IBI classroom practice. The literature indicated that teacher beliefs and goals are the sources, and they shape their instructional practices. However, the findings on the relationship between teacher beliefs and goals to instructional practices have produced mismatched results. My intention in conducting this research study was twofold. Firstly, I wanted to explore the relationship between novice physical sciences teachers' beliefs and goals to their IBI practice. Secondly, I wanted to understand why such a relationship exists between teachers' beliefs and goals to their IBI practice and what influences this relationship. The study addressed the question: *What is the relationship between novice physical sciences teachers' beliefs and goals to their IBI practice?*

This chapter discusses the theoretical frameworks that guided me in exploring, interpreting, and explaining the relationship between novice physical sciences teachers' beliefs and goals to their IBI practice. According to Cohen et al. (2018), the theoretical framework refers to every aspect of the study, from the research questions to the methodology to making sense of the generated data. The theoretical framework assists in the understanding of the phenomenon under study. Considering the mismatch between science teachers' beliefs and goals to classroom practice, I looked for the theoretical framework that will assist me in understanding the relationship between teaching and learning beliefs and goals to IBI practice. I followed the guide by Cohen et al. (2018) that theory helps researchers classify and organise ideas, processes, and concepts from the research conducted. The section below discusses two theoretical frameworks that guided and informed the study's data gathering and analysis.

Constructivism (Dewey, 1933; Piaget, 1936; Vygotsky,1978; and Von Glasersfeld, 1995) was the first framework that provided a clear perspective on novice physical sciences teachers' actions and behaviour related to IBI during classroom practice. Firstly, I frame this study under constructivism because IBI is rooted and founded in constructivist teaching and learning approaches making constructivism an appropriate theory to frame the study (Bybee, 1997). The constructivist theory has been established to be related to instructional methods and can be used to improve science teaching. Secondly, constructivism is regarded as one of the most significant and well-established learning theories in science education (Savasci & Berlin, 2012). As a theory of learning, constructivism has powerful qualities to explain the successes and failures experienced by learners and their teachers. The second framework was Hutner and Markman (2017)'s goal-driven teacher cognition model. It served as a theoretical lens for this study because it provided the model connecting beliefs, goals, and contextual factors to classroom actions. The goal-driven teacher cognition model aided in illuminating the relationship between beliefs and goals in the cognitive process of novice physical sciences teachers.

3.2 Constructivist learning theory

Constructivism is a learning theory and has its roots in the work of educational philosophers such as Dewey (1933), Piaget (1936), Vygotsky (1978), and von Glasersfeld (1995). They have laid the foundations for the contemporary understanding of constructivism. It started with Dewey (1933), who was regarded as the philosophical founder of constructivism. He wrote about the need for humans to construct their knowledge through experience with the environment in which they existed and reflective thinking. Piaget (1936) and Vygotsky (1978) agreed with Dewey that the learner is actively involved in the learning process. Cognitive constructivism originates from Piaget's work on how the individual constructs knowledge. According to him, people construct their own understanding and knowledge of the world through material experiences and reflecting on those experiences. When someone encounters something new, they have to reconcile it with their previous ideas and experience, changing what they believe or discarding the new information as irrelevant. In any case, the learner is an active creator of his own knowledge (Piaget, 1936).

Ernst Von Glasersfeld was one of the leading advocates of radical constructivism. Von Glasersfeld (1995) emphasised that the construction of knowledge and learning takes place on the individual level and exists in the learner's mind. He adopted the relativist position that individuals construct knowledge by giving meaning to their experiences rather than discovery. Learning and knowledge are not waiting to be discovered; instead, humans construct them. However, Vygotsky (1978) was a key proponent of social constructivism. Social constructivism posits that we make, understand, and construct knowledge through interaction with others and the world around us. Vygotsky's (1978) social constructivist theory is premised on learners' selection of activities in which they manipulate situations under minimal guidance. Bybee (1997) added that a social constructivist teacher encourages the active construction of knowledge in learners

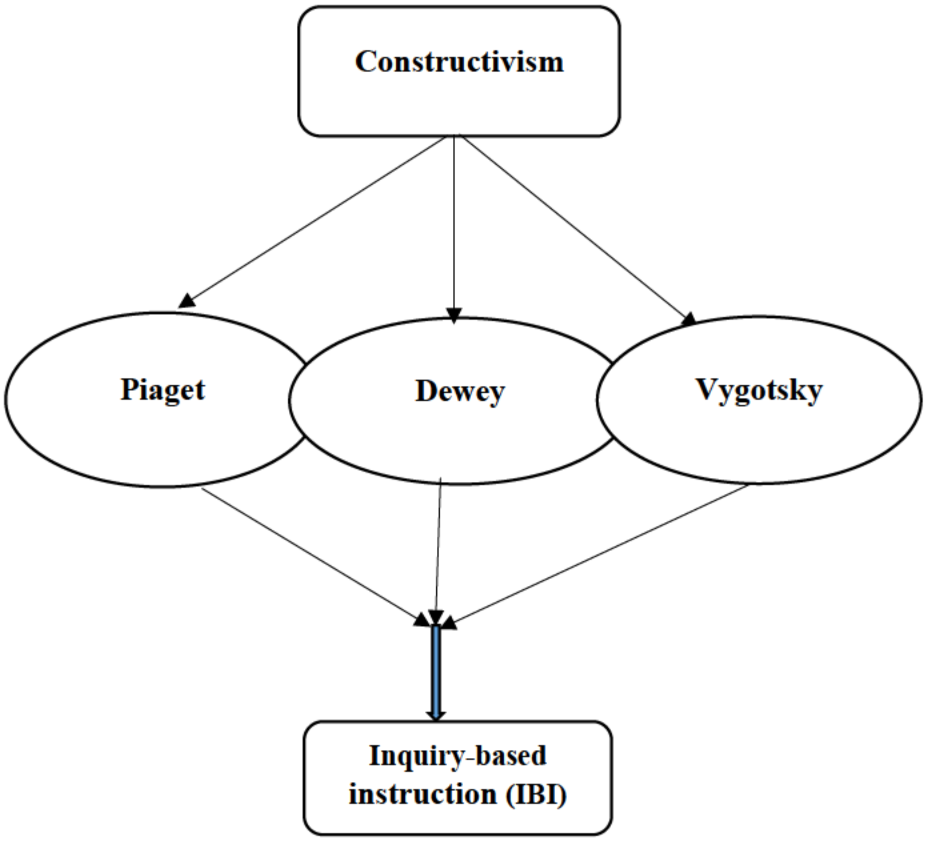
The work of these philosophers was blended into the philosophy of learning known as constructivism (Cakir, 2008), which was then used to shape instructional materials. Even though cognitive, social, and radical constructivists view reality differently and link theory to practice in a different manner, there are common theoretical and practical factors that are essential when applied to constructivist-oriented pedagogy. Central to constructivism is that learners learn through direct experiences, interaction with their environment, and active knowledge construction through negotiating newly presented information or situations with their prior knowledge base to arrive at new understandings (Savasci & Berlin, 2012). As a result, categorisation was not critical in this study since the theoretical positions intertwined well with the basic tenets of constructivist theory. In this study, constructivism is a theory about learning that focuses on the way people learn, not a description of teaching.

3.2.1 Constructivism and IBI

Theorists regard constructivism as a philosophy that cuts across multiple disciplines or a learning model and others as a learning theory (Thomson, 2001). However, regardless of its classification, constructivism is concerned with how personal understanding or knowledge is formed. For example, in this chapter, constructivism is regarded as a learning theory, not a strategy. Constructivism has served as the underpinning learning theory for many current science education reform efforts, including IBI. It has been one of the most influential science teaching and learning theories since the 1980s (Cakir, 2008). In this study, I explored the relationship between novice physical sciences teachers' beliefs and goals about IBI practice. To further support the use of constructivism as a theoretical framework, IBI was born out of a longstanding dialogue about the nature of learning and teaching from the theories of Vygotsky, Dewey, Piaget, Von Glasersfeld, and others. The work of these theorists was blended into the philosophy of learning known as constructivism, and IBI finds its antecedents in all these theories. Figure 3.1 indicates the roots of IBI through the overlap of these theories.

Figure 3.1

Roots of IBI



The illustration in Figure 3.1 indicates the blended and overlap between the work of these philosophers for constructivism. It can be said that IBI is a practical application of the constructivist theory of learning or is motivated by the constructivist theory of learning. Moreover, when the basic elements of the constructivist theory are examined, the links to IBI become clear. Table 3.1 illustrates the alignment between IBI and constructivism theory.

Table 3.1

The alignment between IBI and constructivism theory.

Constructivism	IBI
Promotes learner-centred and self-directed learning	Learner-centred and self-directed learning.
Learners are active participants; hence greater learner engagement	Learners are active participants. Learning is the active process of constructing knowledge
Learning is meaningful because it promotes eliciting prior knowledge and previous understandings.	Learners connect new evidence to prior knowledge or understandings. Learners are not empty vessels that need to be filled. Instead, their existing knowledge serves as an important foundation for new learning.

Promotes the construction of knowledge	Learners actively construct meanings and knowledge and make sense of the world. Learners construct personal meaning and understanding
Promotes higher-level learning, such as reasoning and critical and creative thinking.	Learning tasks should be framed as problem-solving activities requiring the developing and using higher-order thinking skills.
Promotes collaboration which enhances critical thinking	Learners should be working cooperatively with fellow learners and interacting with their instructor. Collaborative learning
The approach to learning involves the process of exploring the natural world in search of new understandings	Knowledge is situated in real - life and, therefore, actively constructs meaning and sense-making of the world

The characteristics of constructivist theory and IBI, as indicated in Table 3.1, were compiled from reviewing the literature (Brooks & Brooks, 1999; Marshall et al., 2010; Richardson, 2003). I believe the principles of IBI aligned well with the theoretical tenants of constructivism, hence the motivation and use of this theory in this study. The novice physical sciences teachers who support the use and engage in IBI should hold the constructivist belief and goals that this type of instruction is best suited to teaching science. In summary, IBI is based on constructivist approaches to learning and teaching and emphasises a learner-centred approach whereby learners construct their own understanding. I, therefore, situate the current study within constructivism.

3.2.2 Constructivist learning environment

Constructivism has grown in popularity, and there is now an emphasis on implementing constructivist ideas in classrooms and other learning environments. When constructivism theory is used in a science education context, a binary is often constructed between teacher-centred and learner-centred teaching strategies that place traditional teaching behaviour in opposition to constructivist teaching behaviour. In chapter one, I indicated that South African science education is dominated by traditional teaching and learning environment. The traditional teacher-centred approaches used in these classrooms do not adequately cater for learners' experiences as advocated by constructivist theory. Constructivism introduced the shift from a traditional, teacher-centred to a classroom environment where learners are the centre of instruction. The constructivist theory has been translated into learner-centred classroom practice, which focuses on learners taking responsibility for their own learning.

The constructivist learner-centred classroom contrasts with the traditional teacher-centred one, which focuses on the teacher being responsible for delivering knowledge to learners. In the traditional learning environment, learners are generally passive rather than active. According to Simmons et al. (1999), during the traditional teacher-centred classroom practice, the teachers' actions will include a presentation of science content, drill and rehearsal of content, use of textbooks as a source of instructional content and learning activities, and low-order tests with only a minor emphasis on applications of information to appraise learner learning.

The constructivist classroom learning environment allows learners to work together and support each other. They use various tools and information resources in their guided pursuit of learning goals and problem-solving activities (Thomson, 2001). For example, according to Simmons et al. (1999), a constructivist classroom affords learners an opportunity to observe, work, explore, interact, raise questions and share their expectations. Similarly, Brooks and Brooks (1999) maintain that the teacher searches for learners' understanding of the concepts and then structures opportunities to refine or revise these understandings in a constructivist classroom. Learners learn by posing contradictions, presenting new information, asking questions, encouraging research, and engaging in inquiries designed to challenge current concepts.

Thomson (2001) used Perkins's (1991) five facets of a learning environment to describe constructivist sources of information and tools. According to Thomson (2001, p. 6), these information resources are:

> Sources of information (information banks), means of expression through writing or other symbols (symbol pads), means of expression through manipulation of pre-existing objects (construction kits), authentic as possible areas for trying out concepts (phenomenaria), and means for undertaking and receiving feedback on specific learning tasks (task managers).

One notes how constructivist learning and teaching environments differ from traditional ones that primarily have textbooks and workbooks. However, it is generally accepted that a teacher shapes the learning environment by what s/he teacher says and does in the classroom. The teaching and learning environment observation was critical to this study as the literature in chapter two indicated how environmental factors impact teachers' beliefs and goals.

3.2.3 Constructivist teacher

The constructivist theory has several implications concerning the teaching approaches and strategies used in the science classroom. Though constructivism does not embody explicit instructional strategies, its premise provides a framework for what is termed constructivist teaching. For example, science teachers shift to a more facilitative role rather than serving as information dispensers as they help learners grapple with the responsibility that comes from being in charge of their own learning. The classification between traditional and constructivist classroom practices is important for this study because I intend to understand how beliefs and goals relate to IBI practice. As I explored novice physical sciences teacher practices, I needed to differentiate and understand whether they are traditional or constructivist through classroom observations.

According to Adams (2006) and Brooks and Brooks (1999), the constructivist teacher understands and uses constructivist principles as guidance in implementing constructivist ideas in classroom settings. Brooks and Brooks synthesised the following principles to guide constructivist teachers. The science constructivist teachers:

1. encourage and accept learner autonomy and initiative
2. use a variety of materials, including raw data, primary sources, and interactive materials, and encourage learners to use them
3. inquire about learners' understanding of concepts before sharing their understanding of those concepts
4. encourage learners to engage in dialogue with the teacher and with one another
5. encourage learners' inquiry by asking thoughtful, open-ended questions and encourage learners to ask questions to each other and seek elaboration of learners' initial response
6. encourage learners in experiences that show contradictions to initial understanding and then encourage discussion
7. provide time for learners to construct relationships and create metaphors
8. assess learners' understanding through the application and performance of open-structured tasks.

These principles address what the constructivist teacher needs to do throughout the course of the instructional process. For example, teachers should solicit and consider learners' ideas and viewpoints to provide lessons that address learners' interests and learning needs (Brooks & Brooks, 1999). Soliciting learners' ideas and viewpoints is especially important as learners come to the classroom with pre-existing knowledge and beliefs that should be challenged to promote learning. Instruction should not only be thought-provoking, but it should be relevant to learners' lives (Brooks & Brooks, 1999). Instruction should be based on what Brooks and Brooks (1999) call big ideas. Focusing on the broader picture requires learners to determine what is essential. It is important to determine what learners learn during instruction. Brooks and Brooks (1999) asserted that learners should be continuously assessed and that the typical, traditional pencil and paper assessments are counterproductive and limiting.

The constructivist classroom is different from the traditional classroom, where the teacher is the primary source of knowledge. In most cases, learners are seated at desks, usually in rows and columns, focusing on the teacher. The teacher may be seen presenting information to learners in one of a variety of methods, such as:

- orally explaining information to learners
- writing on the chalkboard to explain information
- engaging learners in reading exercises related to the concept being taught
- asking or responding to questions
- using teaching aids such as charts, pictures, or models to explain information
- using computer software such as PowerPoint to present information.

3.2.4 Constructivist beliefs

Numerous studies have compared constructivist-oriented to traditional-oriented teacher beliefs. Kaya (2017) observed differences between teachers who had constructivist and traditional beliefs. Constructivist-oriented belief teachers focus on learners' understanding and application of scientific concepts. At the same time, they allocated more time and supported learner inquiry activities or interactive discussions among learners. On the other hand, traditionally-oriented belief teachers tended to emphasize more instructional time on rote and passive science learning, teacher-directed lectures, tutorial problem practices, and learners' test scores. Similarly, Liu (2011) shares the same distinct characteristics of teacher-centred (traditional) beliefs of content knowledge delivery that resemble traditional teaching methods. In contrast to the learner-centred (constructivist) beliefs that emphasise learners' responsibility for learning and focus on knowledge construction and how learners are induced to work and learn together.

Furthermore, regarding beliefs about constructivist teaching and learning, Savasci and Berlin's (2012) framework categorises beliefs from constructivist-oriented to the traditional-oriented teacher. Their five categories continuum included Didactic, Transitional, Emerging Constructivist, Progressing Constructivist, and Expert Constructivist. They adapted the constructivist continuum from the Teacher Pedagogical Philosophy Interview (Simmons et al., 1999). Table 3.2 tabulates the beliefs characteristics as Savasci and Berlin (2012) and Luft and Roehrig (2007) explained.

Table 3.2

Beliefs that characterised a constructivist teacher

Beliefs	Description
Novice	View teaching as the transmission of knowledge and following the curriculum and guidelines
Beginner	Few beliefs aligned with constructivist principles, and they are primarily traditional
Transitional	Beliefs include a balance of traditional and constructivist
Early constructivist	Beliefs include mostly constructivist and a few traditional
Experienced constructivist	Beliefs totally aligned with the tenets of constructivism

Note. This is a summary of the description of the constructivist teaching and learning continuum, Savasci and Berlin (2012, p. 72)

To understand novice physical sciences teachers' beliefs in this study, I used Teacher Belief Interview (TBI) protocol for analysis by Luft and Roehrig (2007). TBI protocol aligns with the constructivist theory and measures beliefs along a continuum from teacher-centred to learner-centred, including five categories: traditional, instructive, transitional, responsive, and reform-based. Traditional and instructive represent teacher-centred beliefs. Responsive and reform-based are more learner-centred. The transitional orientation has both teacher and learner-centred views (i.e., wobbling beliefs) and focuses mainly on teacher/learner relationships. TBI categories aligned with Teacher Pedagogical Philosophy Interviews as they all address the teachers' constructivist beliefs.

3.2.5 Constructivist goals

One of the principles of constructivist theory is that learning is goal-directed. The teaching and learning environment designed with instructional goals helps teachers and learners understand why the content they are working with is important and relevant. During the eighties, Collins (1986) identified three groups of teachers who pursued three distinct goals for inquiry teaching. The first group uses inquiry methods to help learners construct a given theory or set of principles. A second group uses inquiry methods to help learners construct genuinely novel theories or principles. A third group uses inquiry methods to teach learners how to pose questions themselves in order to teach self-monitoring skills (Collins, 1986). However, Honebein (1996) suggested what he described as the seven pedagogical goals from the principles of constructivist learning environments. These goals encourage teachers to embed learning in realistic, relevant, and social contexts and encourage learners' voices in the learning process (Honebein, 1996, p. 12).

The pedagogical goals declared by Honebein (1996) aligned with the IBI goals stated by Chiappetta and Adams (2004). Chiappetta and Adams (2004) emphasized that inquiry-based science instruction should promote; an understanding of fundamental facts, concepts, principles, laws, and theories; the development of skills that enhance the acquisition of knowledge and understanding of natural phenomena; cultivation of the disposition to find answers to questions and to question the truthfulness of statements about the natural world; formation of positive attitudes toward science; and acquisition of understanding about the nature of science (p. 47). The goals mentioned above correspond to teachers' actions and are grounded in IBI. These goals provide insight into what teachers desire to do to realise learner-focused engagement and collaboration.

To further support my choice for constructivism as my framework, it explicitly explains all the constructs explored in this study. The purpose of my study was to explore the relationship between novice teachers' beliefs and goals about IBI. In section 3.2, I have indicated how the constructivist theory aligned with IBI. Furthermore, it explicates the role of a constructivist teacher, beliefs, goals, and environment (i.e., classroom), which I will use as a lens during data analysis. The study on teacher beliefs and goals cannot be divorced from environmental factors. I also included the environment to understand IBI practices for each novice teacher in their different context. However, constructivism does not explain how the teacher's beliefs, goals, and environmental factors relate to each other. Therefore, I looked at how these constructs relate to each other through the goal-driven teacher cognition model.

3.3 The description of a Goal-Driven Model of Teacher Cognition

The second framework I used is a goal-driven teacher cognition model, an emerging model that provides an alternative way of understanding the thinking of science teachers by considering that science teachers' goals drive their instruction or classroom practices (Hutner & Markman, 2017). It also explains the role of knowledge and beliefs in teacher cognition leading to action. It further mentions how contextual (i.e., environmental) factors play an important role in determining the extent to which teachers can implement instruction congruent with their beliefs (Hutner & Markman, 2017).

The first postulate of a goal-driven model of teacher cognition suggests the existence of three mental representations: mediating representation, environmental representation, and goal representation, which are used during the cognitive process to produce thoughts and actions (Hutner & Markman, 2017; Markman & Dietrich, 2000). Firstly, **mediating representation** can represent knowledge, facts, beliefs, and dispositions (Hutner & Markman, 2017). In short, mediating representations can be defined as beliefs, knowledge, and pedagogy that provide information relevant to goal pursuit and necessary action that leads to the satisfaction of such a goal. Hutner and Markman (2017) call these mediating representations because they

> mediate (i) processes of choosing among goals stored in long-term memory; (ii) processes of choosing actions and the subsequent carrying-out of chosen actions in support of a focal goal; and (iii) processes of perceiving external, contextual information (i.e., environmental states), and how it is linked to both the goals of the teacher and the behaviour they exhibit in their role of teacher, both inside and outside the classroom (p. 719).

In this study, I focused on the construct of teachers' beliefs under mediating representation. The constructivist teacher beliefs are discussed in section 3.2.4 above.

Secondly, **environmental representations** also provide information relevant to goal pursuit related to the person's current physical or social contextual condition. According to Hutner and Markman (2017), environmental representations correspond to the physical and social environment of teacher practices. The physical environment provides information through the school's physical structure (e.g., class size and arrangement), curriculum artefacts (e.g., textbooks and teaching materials), and resources. The social environment provides information through school cultures, such as learners' behaviours, department subcultures, and policies. Hutner and Markman (2017) posit that environmental representations provide information that helps teachers decide whether a goal is appropriate or not to pursue at a particular place and time or helps teachers evaluate a goal's feasibility. It also provides information related to affordances and constraints related to attaining a goal that is present in a current context.

Lastly, the **goal representation** corresponds to either the behaviour a teacher will engage in at a future point in time or the desired outcome of such future actions (Hutner & Markman, 2017). For example, the teacher can engage in behaviour to teach through guided inquiry in teaching and learning physical sciences. For example, the desired outcome can be for learners to develop laboratory skills. Goals may be hierarchical, depending on their specificity, as explained in chapter two under the goals section. The hierarchical organisation is based on how the teacher holds his or her goals. Some goals are fundamental, and others are related to or derived from the fundamental goals. For instance, Carver and Scheier (2012) categorized goals hierarchically from general to specific or abstract to concrete. According to Hutner and Markman (2017), using an open inquiry is a pedagogical goal often framed as an abstract goal within the teaching context. The didactic direct, active direct, guided, and open inquiry represented the four pedagogical orientations or overarching goals in this study (Cobern et al., 2014; Magnusson et al., 1999)

The first postulate of a goal-driven teacher cognition model mentioned above clarifies two important points about the relationship between knowledge, beliefs, and goals applicable to this study. The first point is the distinction made between knowledge and beliefs in literature which becomes less relevant in this model. According to Hutner and Markman (2017), knowledge and beliefs are treated as different flavours of the same class of mediating representation as they play the same role in cognitive processes. Some researchers make a distinction between knowledge and beliefs (Mansour, 2009; Nespor, 1987; Talbot & Campbell, 2014)) while others (Kagan, 1992; Fajardo, 2013) treat them as similar. According to the goal-driven model of teacher cognition, beliefs and knowledge function in the same way in cognitive processes by mediating between information drawn from the environment and cognitive outputs. In this regard, Hutner and Markman (2016) define beliefs and knowledge operationally instead of epistemologically, focusing on the role each plays in cognition leading to action.

The second point is that goals are distinct representations from knowledge and beliefs (Hutner & Markman, 2017). As mentioned in chapter two, several studies had treated goals as the same as knowledge and beliefs or subsumed goals under knowledge and beliefs (Kang, 2008; Kang & Wallace, 2005; Friedrichsen et al., 2011; Webel & Platt, 2015). According to Hutner and Markman (2017), the type of information inherent to goal representation and mediating representation is not the same. According to the goal-driven model of teacher cognition, it is possible for a science teacher to have knowledge about IBI and beliefs supportive of the use of IBI without holding or activating a goal corresponding to the use of that approach in a particular context.

The second postulate of a goal-driven model of teacher cognition is that not all representations stored in long-term memory are used during each cognitive process; instead, only active representations take part in a given cognitive process (Hutner & Markman, 2017). The cognitive process makes use of the active goal, environmental, and mediating representations. The result of this process could be an action or a new representation, i.e., mediating or goal. The activation of one representation will lead to the activation of other related representations. Thus, active goal representations will activate mediating representations (i.e., beliefs or knowledge) that will likely be useful to attain the active goal. The implication is that if the goal of teaching through inquiry is active, knowledge and beliefs about IBI will be used for goal attainment. An active goal will also direct attention toward potential affordances for or constraints preventing goal attainment in the environment, activating specific environmental representations from the plethora of information that could be drawn from the environment. At the same time, active mediating representations can activate related goal representations. Thus, for example, beliefs about IBI can activate a goal related to teaching science through inquiry. Similarly, environmental representations can activate goal representations, particularly if the environment provides affordances for goal attainment.

Hutner and Markman's (2017) second postulate challenges the assumption that beliefs have a causal relationship with classroom practices. The model does not assume a direct relationship between beliefs and actions. For example, a science teacher can hold learner-centred beliefs about IBI with classroom practices congruent with such beliefs or vice versa. According to Hutner and Markman (2017), beliefs and knowledge can influence classroom practices only when they are activated to take part in cognitive processes. Hutner and Markman's second postulate addresses research evidence over the gap between beliefs and classroom practices that have continued to exist over the years. As mentioned in chapter two, several authors assume a direct relationship between teacher beliefs and knowledge and their classroom practices, tacitly or not.

The central postulate, which is a crux of a goal-driven model of teacher cognition, is that cognition is goal-driven (Hutner & Markman, 2017). Put simply, teachers act in ways that lead to the satisfaction of one or more of the goals they hold. This model suggests that 'classroom practice is a response to a goal that is active in cognition during planning and teaching' (Hutner & Markman, 2017, p. 716). Consistent with this postulate, Castelfranchi (2016) suggests that goals are the centre of gravity of the mind, which on the basis of knowledge, drive people's behaviour. According to Hutner and Markman (2017), the theoretical perspective of a goal-driven model of teacher cognition proposes that it is possible for a teacher to hold knowledge and beliefs but exhibit classroom practice incongruous with said knowledge and beliefs. The mediating representation of specific knowledge or belief will fail to influence a science teacher's classroom actions in cases wherein a goal consistent with those particular representations is not activated. The possible reason for this is if the environment does not support the activation of the goal, or another goal is more strongly activated in the cognitive process, or the goal itself does not exist in memory. Regardless of science teachers having learned about a particular instructional approach, if the goal to use that approach is not active during planning and teaching, the teachers will not use that approach. A science teacher may believe that a particular instructional approach is valuable and may even express the importance of that approach in discussions about teaching, and may still fail to use that approach in the classroom. Without a goal to use an approach or viewing the approach as satisfying one of the goals, a teacher may know the approach is valuable but will not engage that approach in the classroom. Therefore, identifying teaching goals provides a clearer understanding of teachers' actions in the classroom (Kang, 2008).

Using the goal-driven teacher cognition model, I subscribed to the goal hierarchy approach explained in chapter two under the goals section. In hierarchical goal systems, goals are not isolated from each other but are related or interconnected to activate each other. (Aguirre & Speer, 2000; Höchli et al., 2018). At a higher level are overarching, followed by major instructional (i.e., intermediate) and specific goals at the lowest. The goal activation can be top-down or bottom-up activation (Höchli et al., 2018). For example, in a bottom-up activation, the science teacher engages learners to learn facts and terms, and the intermediate goal to develop knowledge and skills is automatically activated, thus activating a guided inquiry goal. In their study, Aguirre and Speer (2000) did not subscribe to the goal hierarchy approach because they used belief bundles to observe goal shifting.

3.3.1 The goal-driven model with other theories or models

The goal-driven model of teacher cognition has some similarities and differences with previous models of science teacher cognition. Schoenfeld's (1998) theory of Teaching-In-Context pays attention especially to the three fundamental parameters of knowledge, goals, and beliefs. The main claim of his theory is that what people do is a function of their knowledge, goals, and beliefs. Schoenfeld (1998) originally perceives goals and beliefs as two distinct parameters that, together with knowledge, allow for understanding and explaining a teacher's actions in the classroom. Even though Schoenfeld stresses the interplay of beliefs and goals, beliefs are given priority over goals as they serve to re-prioritize goals. Schoenfeld (1998) highlights that a shift in a teacher's goals provides an indication of the beliefs he or she holds. Furthermore, he states that beliefs influence both the prioritization of goals when planning the lesson and the pursuance of goals during the lesson. As Schoenfeld (2010) stresses: 'a teacher's beliefs and values shape the prioritization both of goals and knowledge employed to work toward those goals' (p. 8).

One similarity between Schoenfeld's (1998) and Hutner and Markman's (2017) study is both consider goals and beliefs distinct constructs. This similarity implies no equal interplay between knowledge, beliefs, and goals in teacher cognition. However, the main difference is that Schoenfeld's model prioritizes beliefs, whereas Hutner and Markman's model considers goals to drive actions. Even though Schoenfeld claims that what people do is a function of their knowledge, goals, and beliefs, the Markman model considers only the active representations (i.e., knowledge, beliefs, and goals) to influence cognition.

The PCK theory by Shulman (1986, 1987) mainly focused on content knowledge and pedagogical content knowledge (Shulman, 1987). Magnusson et al. (1999) adapted a model Grossman (1990) proposed to conceptualize PCK for science teaching consisting of five teaching orientations. These models were discussed in chapter two under the knowledge section. Both models consider teachers' goals as a form of knowledge. However, in Shulman's model, goals are treated as their own form of knowledge, whereas in the Magnusson et al. (1999) model, goals are treated as a component of PCK. Research studies that use PCK as a framework suggest a direct relationship between it and pedagogical approaches. For example, science teachers with strong content and pedagogical knowledge are more likely to engage in inquiry-based pedagogical approaches (Van Driel et al., 2014).

The goal-driven teacher cognition model is similar to PCK as it considers the interplay of knowledge, beliefs, or goals in teacher cognition. However, it differs from PCK models in three important ways. Firstly, as mentioned above, the model driving this study suggests that a teachers' goals are distinct cognitive structures separate from knowledge and beliefs. The PCK model, in contrast, treats goals as a subset of beliefs or knowledge. The second way this study model differs from the PCK is the assumption of the equal interplay of knowledge, beliefs, and goals in a teacher's cognition leading to classroom practices. Thus, it stands in contrast to this study model, which assumes that cognition is goal-driven. In Hutner and Markman's model, the third distinction is that only the active representations influence cognition. PCK has not yet integrated the concept of activation, even though this concept can also be applied to beliefs, knowledge, and PCK models.

3.3.3 The prior use of the goal-driven model

A goal-driven model of teacher cognition is an emerging model that considers goals as the driver of cognition, i.e., teachers act in ways that lead to the satisfaction of one or more of the goals they hold. Few studies have used the model to explore or resolve what Hutner and Markman (2017) referred to as two anomalies in science education. The first anomaly is that research has been unable to account for why so many science teachers are quick to discard the pedagogy and practices promoted in their teacher education courses, even when professing to believe in those pedagogical approaches. The second anomaly is that researchers have been unable to answer why science teachers profess to use and believe in the pedagogy and practices emphasized in their teacher education program while teaching in a manner that suggests they hold traditional beliefs and pedagogy (Hutner & Markman, 2017).

In the recent study, Rojas-Perilla (2018) used the goal-driven teacher cognition model and the cognitive demands to frame his study, exploring pre-service science teachers' beliefs and goals on the cognitive demand of the learning tasks they design. He conducted a cross-case analysis using qualitative methods to examine the influence of beliefs and goals. Data was collected through participant interviews and document analysis. The findings from his study were consistent with the theoretical premises of the goal-driven teacher cognition model. Results suggested that pre-service teachers' goals were influenced by their beliefs about teaching and learning science and the contextual characteristics of their teaching practices placement. Moreover, pre-service science teachers were able to operationalize their beliefs into learning goals for their learners, including explicit epistemic goals that seek to engage learners in using science practices to make sense of disciplinary ideas. Rojas-Perilla suggested that helping student teachers develop and pursue goals that characterize high cognitive demand tasks has the potential to improve their teaching practices.

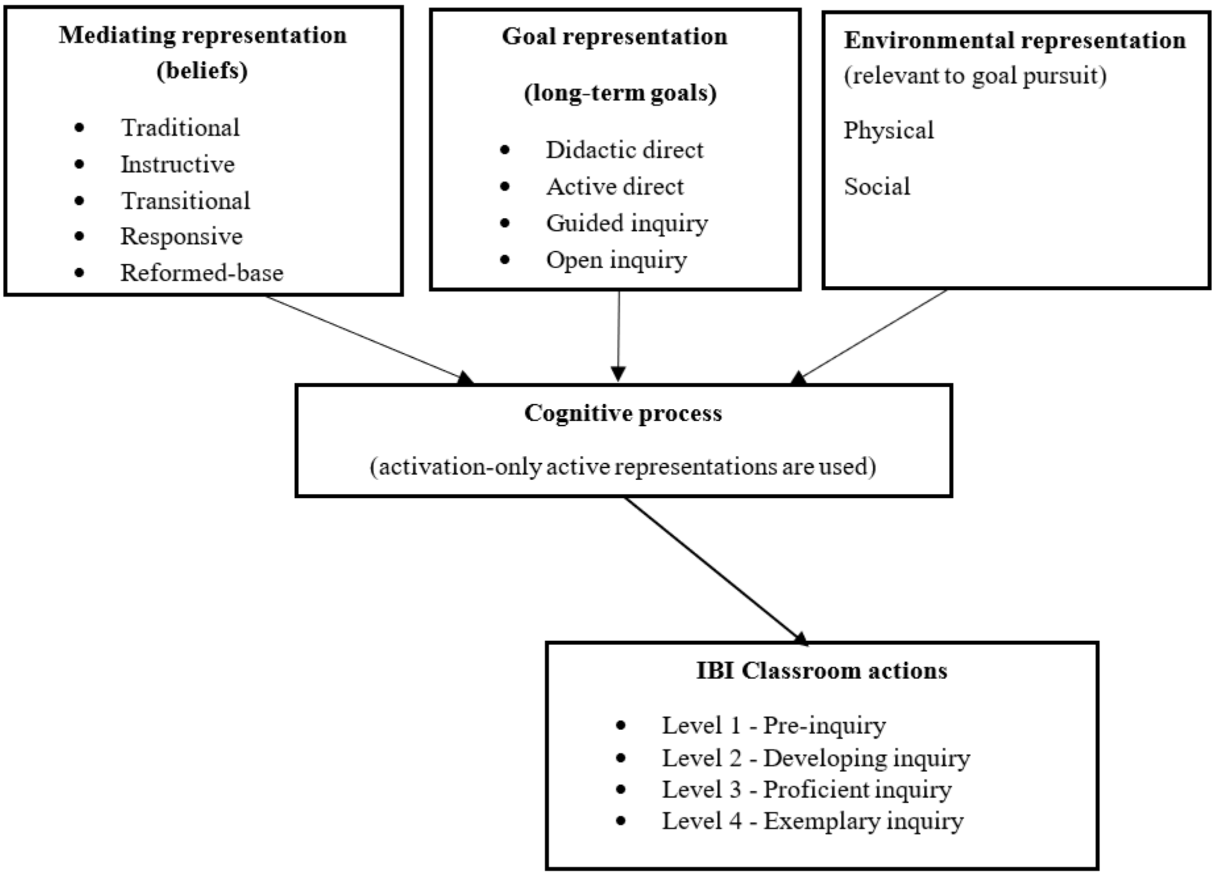
In their study, Hutner et al. (2019) use a goal-driven theory of cognition to understand the extent to which pre-service science teachers align with the instructional practices emphasized in teacher education. This was a qualitative case study, and interviews and physical artifacts (i.e., portfolios) were used to gain insight into student teachers' thinking. In the presentation of their findings, they indicated that pre-service science teachers do develop many, but not all, goals reflective of the instructional practices emphasised in their teacher education program. They proposed that part of the reason for this finding may be due to a lack of integration of such approaches into their goal representations. The second finding revealed that conflict might arise between pedagogical goals, with student teachers resolving these conflicts in research-based and less than ideal ways. Thus, the goal conflict may also contribute to the inconsistency between teachers' self-reported and observed classroom practices. The implication from their studies is that teacher educators need to engage in efforts to help pre-service science teachers develop goals reflecting the pedagogy and practices emphasized in teacher education. Moreover, they should help pre-service science teachers resolve goal conflicts in productive ways.

3.4 Summarising the frameworks

I made propositions for the three research questions using the constructivism theory and the goal-driven teacher cognition model and answered the main research question. I wanted to address the main research question: *What is the relationship between novice physical sciences teachers' beliefs and goals about IBI to their classroom practices?* The constructivism theory provided the understanding of the beliefs continuum the novice physical sciences teachers hold about IBI and classroom practices. It also suggested the teachers' goals pursued in the constructivist learning environment. The goal-driven teacher cognition model explained the relationship between beliefs and goals to classroom practices. The understanding of the relationship was provided by the interplay of beliefs and goals to the novice physical sciences teachers' classroom practices. Figure 3.2 illustrates the framework which guided the study, combining goal-driven teacher cognition and constructivism in analysing novice physical sciences teachers' beliefs and goals about IBI to classroom practices.

Figure 3.2

Relationship beliefs and goals about IBI to her classroom practices



The first sub-research question: *What beliefs and goals do novice physical sciences teachers hold about IBI?* I used Luft and Roehrig's (2007) interview protocol explained in section 3.3.1 for teaching and learning beliefs to understand this question. The constructivist theory proposition was between teacher-centred (didact and active direct), learner-centred (responsive and reformed based), and transitional beliefs about teaching and learning. Constructivism also presented an understanding of the overarching pedagogical goals and IBI classroom practices. Chiappetta and Adams (2004) and Honebein (1996) described the goals pursued by the constructivist teacher during IBI practices.

The second sub-research question: *How are novice physical sciences teachers' beliefs and goals about IBI reflected in their classroom practices?* The understanding linked to this research question was from pre-inquiry to exemplary inquiry. I used EQUIP (Marshall et al.,2010) to measure the quality of IBI in the classroom. The comparison of both instruments (TBI and EQUIP) with the constructivist pedagogy by Brooks and Brooks (1999) indicated that they cover a constructivist-based pedagogy's basic requirements.

The third sub-research question: *Why do novice physical sciences teachers exhibit beliefs and goals about IBI to their classroom practices in the manner that they do?* The understanding of this question was informed by what was happening in the novice physical sciences teacher's cognitive process. For example, if the novice physical sciences teacher's classroom practices did not align with one of the representations, the explanation could be:

(i) the goal to teach with such an approach does not exist;

(ii) the goal does exist, but other goals are more readily activated in cognitive processes related to teaching and learning science;

(iii) the environmental representations currently active do not support the activation of goal and/or mediating representations reflective of methods emphasized in teacher education; or

(iv) the methods emphasized in teacher education, while learned, are not viewed as viable routes to satisfying the goals active during planning and teaching (Hutner & Markman, 2017, p.723).

3.5 The chapter summary

The chapter has presented the constructivism theory and the goal-driven teacher cognition model that frame the study and provided a lens that informed data analyses. The constructivism theory suggests the teachers' constructivist beliefs and learning environment. The goal-driven teacher cognition model explained the relationship between beliefs (mediation representation) and goals (goal representation). In the next chapter, I discuss the research design and the methodology used to address the research questions raised in this study.

CHAPTER FOUR
RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

The previous chapter presented the theoretical frameworks, goal-driven teacher cognition, and constructivism learning theory to understand the complexities of the relationship between beliefs and goals to their IBI practices for novice physical sciences teachers. In this chapter, I present the research design for this study on novice physical sciences teachers' cognition about IBI in an attempt to understand the relationship between their beliefs and goals to their IBI practices. Research design's significant advantage is its rigour to the research process as it describes how the research has been conceptualised and planned. Research design helps ensure that the research is systematically conducted and accountable for the research's quality and claims. Creswell and Poth (2018) refer to the research design as 'the entire process of research from conceptualising a problem to writing research questions and on to data gathering, analysis, interpretation, and report writing' (p.5). Employing the research design discussed in this chapter, the study addressed the question: *What is the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices?*
This critical research question was addressed through the following sub-questions:

1. What beliefs and goals do novice physical sciences teachers hold about IBI?
2. How do novice physical sciences teachers' beliefs and goals relate to their IBI practices?
3. Why do novice physical sciences teachers' beliefs and goals relate to their IBI practices in the manner that they do?

Although these questions were stated in chapter one, they are presented here at the start of the research design chapter to inform the current discussion. This chapter's research design and methodology include the discussion of constructivism as the research paradigm and the qualitative approach using a multiple-case study design. The chapter further describes the research sample and its selection. I broadly describe the data gathering sources and the procedure I followed to collect and analyse data. I conclude this chapter with a discussion of ethical considerations.

4.2 Research paradigm

Adopting a suitable paradigm is crucial for all research since it allows the researcher to make sense of the world. A research paradigm is defined as beliefs that guide researchers' actions about the world and how it should be understood and studied (Denzin and Lincoln, 2011). Given the nature of the research questions and the complexity of studying novice physical sciences teachers' beliefs, goals, and classroom practices, I operated within the interpretive paradigm, i.e., social constructivism, according to Creswell and Poth (2018). The social constructivist paradigm, as defined by Creswell and Poth (2018), is also referred to as interpretive by Cohen et al. (2018) or interpretivism by Denzin and Lincoln (2011). Social constructivism is a philosophical or worldview based on the assumption that individuals seek multiple, subjective understandings of the world in which they live and work (Creswell & Poth, 2018; Denzin & Lincoln, 2011). Its focus is on exploring complex, multiple subjective meanings and understandings that participants assign to their world experiences (Creswell & Poth, 2018). According to Lincoln and Guba (1985), the social constructivist paradigm is most appropriate when conducting an inquiry into the human experience. As discussed in the following sections, social constructivism was deemed a suitable paradigm for this study because of its assumptions and views.

The social constructivist paradigm addresses the perspective of the unique experiences of the individual and explores how the individual makes sense of their experiences to construct an understanding of the world (Creswell & Poth, 2018). In chapter three, I used constructivism as a learning theory to interpret and understand novice physical sciences teachers' classroom practices in a constructivist learning environment. In a constructivist classroom, knowledge is constructed individually and socially, whereby learners are active and collaborative work is done. I used social constructivism as a philosophical and methodological paradigm in this chapter. This paradigm ties on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in and how that new knowledge is incorporated into the existing knowledge. Thus, novice physical sciences teachers observed were constructing knowledge and beliefs through their interpretation of the events taking place in the classroom. According to Magnusson et al. (1999), beliefs about science teaching and learning are constructed from experiences with learners and formulated within the context of the classroom to influence instructional decisions and subsequent actions during teaching. In this study, social constructivism guided my beliefs that IBI happens through social interaction, and science teachers' beliefs and goals are central to that interaction. I wanted to understand, through interpretation, novice physical sciences teachers' beliefs and goals about IBI rather than accept its universal laws. In the constructivist view, meaning is not discovered but is constructed as we engage in interpreting our world. Moreover, the social constructivist paradigm suggests that knowledge is co-constructed between the study participant and the researcher. So, as stated by Creswell and Poth (2018), the construction of multiple realities can only be studied holistically when the researcher and participant interact with and influence one another.

The social constructivist paradigm is embedded in ontology, epistemology, and methodology ideology. Ontology is a branch of philosophy concerned with the views about the nature of reality (Creswell & Poth, 2018). The fundamental ontological assumption of social constructivism advocates for the existence of multiple realities constructed by people and that there is no one reality or single truth (Creswell & Poth, 2018). These realities exist as the production of manifold mental construction. They can be found in human minds as they are generated from the interaction between their cognitive process, culture, and social context in which they live. These mental constructions or multiple realities could be different or conflicting regarding the individuals' differences in their lived experiences and social influences (Creswell, 2013). In this study, I considered that each novice teacher had unique beliefs and goals about teaching and learning and used a unique lens to construct meanings. The concept of multiple interpretations of any event, as experienced by participants, was evident during data gathering for this study. Each novice physical sciences teacher held unique beliefs and goals to IBI practices and used a unique lens to construct meaning. The constructivist perspective provided a means of gaining insight into novice physical sciences teachers' different beliefs and goals and their relation to IBI practices, which are constructed individually, hence multiple realities. By maintaining a constructivist perspective, my analysis did not focus on finding one correct answer or generalisation but rather on developing a deeper understanding of their cognition to understand these multiple realities. The social constructivist ontology ideology assisted in revealing the meanings articulated by novice teachers in their beliefs, goals, and actions. The novice teachers' language and direct quotes were merged into thick, rich descriptions for a truthful interpretation of their perspectives.

Epistemology is the philosophy concerned with how knowledge is constructed (Creswell, 2013; Creswell & Poth, 2018). According to Denzin and Lincoln (2011), individuals actively engage in meaning construction from their experiences as they interpret and draw conclusions based upon their unique perspectives, experiences, and assumptions. Hence, within the context of education research, teachers construct their teaching and learning knowledge and beliefs through their experiences in the classroom as learners influence the nature of this knowledge and beliefs. One of the important implications from the above perspective was that my data interpretation and analysis played a vital role in meaning construction. In this study, I focused on understanding the relationship between beliefs and goals to the IBI practices of novice physical sciences teachers in their natural world. I believe that to understand the world, I must interpret, i.e., make sense of the underlying meanings of events and activities. To interpret the world requires co-constructing knowledge between the study participants and the researcher (Creswell, 2013; Creswell & Poth, 2018). Informed by the epistemology of the social constructivism paradigm, I constructed meanings of the novice physical sciences teachers' beliefs and goals to their IBI practices in an effort to describe and interpret them. I immersed myself in the realities of novice teachers through close interactions. In this regard, I observed the realities of the lives of novice physical sciences teachers as participants during the study and constructed ideas and meaning out of their voices and behaviour during classroom practices. Furthermore, I applied an inductive data analysis approach as I worked back and forth to make sense of the data. The inductive analysis approach seeks to understand particular social phenomena from individuals' perspectives and does not require people to confirm predetermined answers (Creswell, 2013; Creswell & Poth, 2018).

The social constructivist paradigm endorses the general research methodology, particularly selecting participants, instruments, tools, and methods used in this research study. This forms the basis of the methodological assumption where flexible research tools facilitated participants' advent of the studied social situation. Flexibility was required because this study was shaped by the responses I received from the participants. Hence, I adopted data gathering methods such as open-ended questionnaires, classroom observations, and stimulated recall interviews (see section 4.6). I become cognisant of their realities through the text created in questionnaires and letting them speak for themselves (Denzil & Lincon, 2011, 2018).

4.3 Research approach

Informed by the social constructivism paradigm and research questions stated in 4.1, I employed a qualitative research approach in this study. According to Denzil and Lincoln

(2011), the qualitative approach 'involves an interpretive, naturalistic approach to its subject matter; it attempts to make sense of, or interpret, phenomena in terms of meanings people bring.' The qualitative study lends itself to a thick description of the phenomena through interpretation and sense-making. Furthermore, Merriam and Tisdell (2015, p. 24) add that qualitative researchers seek to understand '(1) how people interpret their experiences, (2) how they construct their worlds, and (3) what meaning they attribute to their experiences'. Merriam and Tisdell's features informed my choice of qualitative approach.

This study focused on understanding the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices. Studying teachers' cognition meant exploring their inner lives, beliefs, goals structures, and how they interplay with IBI practices. The qualitative approach was appropriate for this study, which requires exploration and a detailed understanding of teachers' inner experiences. As Corbin and Strauss (2008) corroborated, qualitative research allows the researcher to understand the participants' inner experience, determine how meanings are formed through and in culture and discover rather than test variables. In exploring teachers' inner lives regarding IBI practices, it was imperative to study them within the natural settings of their classrooms. Teachers' beliefs and goals about what and how to teach are revealed during planning and classroom practices. Thus, the qualitative approach provided important features for studying the research questions.

One of the features of qualitative study is to elicit understanding and meanings (Merriam, 2009). The qualitative research approach contributed immensely to understanding the relationship between novice physical sciences teachers' beliefs and goals about IBI practices. One explanation for this is that this approach tolerated the study of the phenomena through direct interaction with the research participants in their natural settings (Creswell, 2013; Denzil & Lincoln, 2011), which enhanced the meanings behind their observed behaviour (classroom practices). Through a qualitative approach, I obtained a clearer perspective on the relationship between beliefs and goals to IBI practices by observing teachers' actions in their natural environment and interpreting their stated meanings of events as they experience them. The data gathering sources (see section 4.6) allowed me to develop holistic views from their own words and actions on science teacher cognition about IBI.

Moreover, the critical research questions addressed in this study aligned well with the qualitative approach goals. They aimed to produce a rich descriptive qualitative analysis emphasizing a deep, interpretive understanding of science teachers' cognition of IBI practices. The research questions in 4.1 (i.e., what, how, and why) allowed for flexibility in open-ended and less structured teachers' responses on their beliefs, goals, and actions. The qualitative data from teachers' responses did not use statistical analysis but an in-depth understanding of participants' perspectives and perceived the world through their lenses. As Yin (2014) suggested, qualitative research represents other people's or participants' views and covers the contextual conditions within which people live. Operating within a qualitative research approach enabled me to depict facts or reality about novice physical sciences teachers' cognition from my and the participants' perspectives. The exploration of meaning is central to qualitative research.

The qualitative research approach allowed the study to capture the qualities and attributes of novice teachers' beliefs and goals without measuring or counting. It improved my understanding of the complex relationship between beliefs and goals to IBI practices. It was an approach of choice for most researchers who explore teachers' knowledge, beliefs, and orientations (Borg, 2009; Fives & Buehl, 2012; Kagan, 1992; Kind, 2016; Pajares, 1992). Pajares (1992) asserts that:

> understanding teacher beliefs requires making inferences about individuals' underlying states, inferences fraught with difficulty because individuals are often unable or unwilling, for many reasons, to represent their beliefs accurately. For this reason, beliefs cannot be directly observed or measured but must be inferred from what people say, intend, and do. (p. 314).

As Pajares (1992) and Fives and Buehl (2012) pointed out, understanding teachers' beliefs, which are regarded as messy constructs, involves making inferences because beliefs cannot be directly measured or observed but must be inferred from what participants say, intend, or do. The qualitative approach was suitable for gaining an understanding of novice teachers' messy constructs and their relation to IBI practices.

4.4 Case study design

Merriam and Tisdel (2015) argue that no other word in qualitative research comes with multiple interpretations as a case study because it resembles casework, case methods, or case methodology. The all-embracing definitions of a case study make it the most ambiguous term, lending itself to multiple interpretations. Although the definition of a case study from multiple researchers may overlap and be similar in a way, I chose a defining description of how the case study was selected. The operational definition I decided to adopt for this case study was:

> a qualitative approach in which the investigator explores a real-life, contemporary bounded system (a case) or multiple bounded systems (cases) over time through detailed, in-depth data gathering involving multiple sources of information (e.g., observations, interviews, audio-visual material, and documents and reports), and reports a case description and case themes. (Creswell & Poth, 2018, pp. 96-97).

Unlike other definitions, the above case study description accentuated the dimensions of a research design that influenced my choice of a case study.

Firstly, I considered the study on novice physical sciences teachers' cognition about IBI as a real-life case of interest and has extensive implications for sciences education communities and higher education institutions. Moreover, the particularistic feature of a case study (Merriam, 2009; Yin, 2017) is understood in the sense of embracing the complexity of real-life events through which the discrepancies of viewpoints held by participants can be represented and supported. As Merriam (2009) suggested, the case study is appropriate when research has questions related to interesting aspects of educational activity, programme, or systems. The questions in this study focused more on asking how and why, as opposed to, for example, how many. This made case study an appropriate research design for the research questions providing an in-depth understanding of the phenomena. Since teacher cognition is a hidden and central aspect of science teachers' professional lives, the case study allowed me to grapple with these issues by probing deeply with novice physical sciences teachers.

Secondly, the case study can be bounded in multiple ways. The bounded system can be a group of people who show dynamic and relevance, revealing information captured within fixed parameters. This study's group was bounded because they were novice physical sciences teachers. They also studied at the same university for their undergraduate teaching degree. I claimed the novice teachers had a background in physical sciences teaching and used IBI. Lastly, based on the purpose of this study, I used suitable data gathering sources. Yin (2017) advised that case studies require multiple methods to capture the case's depth. Multiple methods are an inclusive and detailed strategy that enables researchers to explore the problem from various perspectives, making it practically valuable. Furthermore, this allowed for rich-information data to be analysed, seeking patterns of data to develop and triangulate critical observations. I applied the criteria identified in the above definition to this research study as indicators for a case study to be a suitable research design.

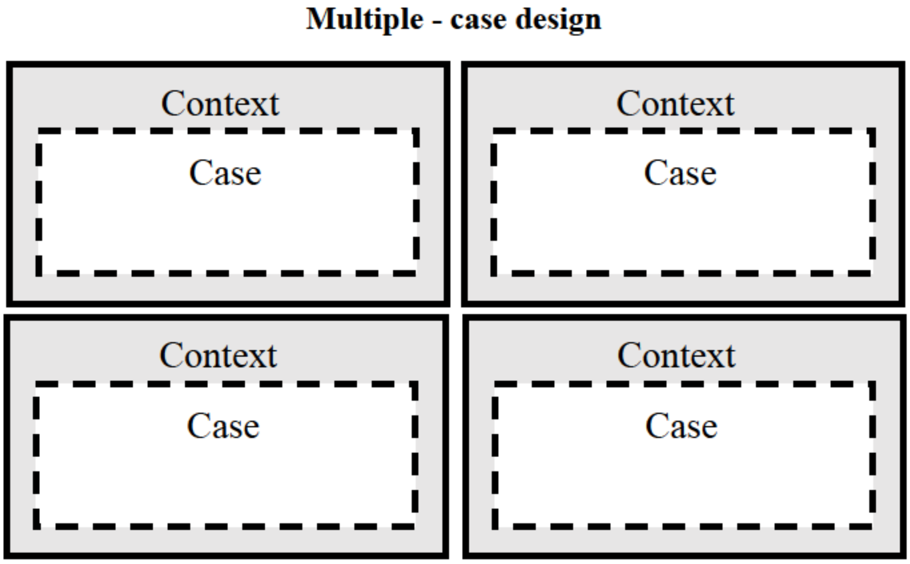
There are different case studies, and I adopted a multiple-case study design for this study (Yin, 2017). Stake (2006) describes multiple case studies as suitable for exploring how a phenomenon operates in different environments. Using a multiple-case study goes along with Yin's (2017) suggestion that the chances of doing a good case will be better even with doing a 'two-case study than using a single-case design.' Although data was collected from four novice physical sciences teachers, which is not a more significant number, it offers an opportunity to probe their beliefs and goals regarding IBI practices, thus generating rich data. Rich data came from the cross-case analysis technique, which provides vital characteristics to a case study (Yin, 2017). Furthermore, Stake (2006) states that an important reason for doing the multiple case study is to explore how the program or phenomenon performs in different environments.

Moreover, a multiple-case study design uses the logic of replication in which the researcher replicates the procedures for each case. Each case offers an insight into teacher cognition within its natural context. Thus, a cross-case analysis strategy allowed for a more significant variation across cases which compelled more interpretation (Merriam, 2009). It also gave the study's conclusion more power as it allowed the four cases to be studied in different contexts (i.e., schools). Merriam and Tisdell (2016) added that multiple cases improve the external validity of the findings. Multiple cases allow for replication logic to be applied to the study findings. Replication logic corroborates and extends the findings beyond the first case.

Yin (2014) identifies four case study design scenarios, single-case and holistic, single-case and embedded, multiple-case and holistic, or multiple-case and embedded. This study is multiple-case and holistic. Figure 4.1 indicates the type of multiple-case design chosen for this study.

Figure 4.1

Yin's (2014) case study designs



This study is a multiple holistic case design that includes four novice physical sciences teachers' cases from different school contexts. Yin (2014) differentiated between these designs, explaining that there is only one unit of analysis in a holistic study (single or multiple). In contrast, there is at least one additional subunit within the unit of analysis or case in an embedded study.

The significant benefit of a case study is that it allows for an intensive study of the phenomenon. However, the case study also brings a limitation on generalisation issues. One of the limitations of a case study is that it may not be generalisable though results may be transferred to a similar context (Cohen et al., 2018). However, my intention was not to obtain generalisable information but to clearly understand novice physical sciences teachers' cognition about IBI. I was interested in the process of understanding teacher cognition rather than the outcome. My choice of a case study was based on its uniqueness and capacity to gain an in-depth understanding of the complex situation and meaning for those involved (Merriam & Tisdell, 2015; Yin, 2017). This quest for in-depth understanding made a multiple-case study an appropriate design for this study.

4.5 Case Selection

I purposively selected four novice physical sciences teachers, two females and two males, for this study. Cohen et al. (2018) described purposive sampling as a non-probability sample where the researcher selects a particular group from the population for a specific reason. Moreover, they added that participants are intentionally chosen in purposive sampling due to their appropriateness in enhancing the research aim. I embraced Davis et al. (2006) argument that novice science teachers (i.e., teachers in their first five years of practice) are critical for implementing a reform-based curriculum and are most likely to espouse and encourage reform-oriented instruction (see chapter 1, section 1.5). Furthermore, the assumption is that novice teachers' beliefs are less stable and less resistant to change. I decided to choose four among the district's cohort of novice physical sciences teachers because I wanted my ex-students as in-service novice teachers. They were all acquainted with IBI and motivated to develop inquiry activities to facilitate science learning. I wanted novice teachers I worked with during their undergraduate teacher education programme. Keeping with the conceptualisation of data generating in explorative and multiple perspectives through the study of individuals, I thought that novice physical sciences teachers might be comfortable with my classroom observation since I had observed them numerous times during teaching practices. I had developed rapport and trust with these novice physical sciences teachers that will enable me to probe and question them more easily. They are used to questioning regarding their planning and teaching. It was essential for me to select participants who would contribute to a deep understanding of the research phenomenon of science teachers' cognition about IBI. Patton (2015, p. 53) asserts that 'the logic and power of purposive sampling derive from the emphasis on an in-depth understanding of specific cases: information-rich cases'. My interest was the four novice physical sciences teachers' success as quality teachers and their professional development.

There are no clear rules about the number of participants in a sample in qualitative research. I selected four novice physical sciences teachers from different schools and classroom settings. According to Denzil and Lincoln (2018), the forte of a case study is working with small samples studied in depth. I believed that selecting four novice physical sciences teachers would not be too small to provide me with data to answer research questions simultaneously and not too big to make it challenging to extract thick data. Selecting a heterogeneous sample assisted me in identifying common patterns that captured novice teachers' beliefs and goals about the IBI practices of the entire group. Patton (2015) suggests that when selecting a small sample of great diversity, the data gathering and analysis will yield important shared patterns that cut across cases and derive their significance from having emerged out of heterogeneity. Table 4.1 summarises the research sample and the detailed background information of teachers in the following chapters. I used pseudonyms to identify the participants in this study. In the following chapters, I will give the details of their schools and classroom setting.

Table 4.1

Background information of novice physical sciences teachers

	Amalia	Wayde	Nelisa	Gatsha
Gender	Female	Male	Female	Male
Age	20-29	20-29	20-29	20-29
Major subjects	Physical sciences Mathematics	Physical sciences Life Sciences	Physical sciences Mathematics	Physical sciences Mathematics
Highest qualification	BEd	BEd	BEd	BEd
Current registration	BEd (Honours)	Not studying	BEd (Honours)	BEd (Honours)
Years of teaching	3	1	4	3

4.6 Data Gathering methods

This study was framed within an interpretive framework abiding by a social constructivist worldview that focuses on exploring multiple subjective understandings or meanings the participants assign to their world experiences (Creswell, 2013). This worldview allowed me to explore the relationship between novice physical sciences teachers' beliefs and goals to IBI practices. My objective was to get into their thinking and understand it from within. To provide this holistic understanding, I used multiple data sources. I used open-ended questionnaires, the Pedagogy of Science Teaching Test (see Appendix 2A), and the Teaching Goals Inventory (see Appendix 2B). I used the Teacher Beliefs Interview (see Appendix 2C) as a pen-and-paper interview. I used the Electronic Quality of Inquiry Protocol (EQUIP) for classroom observations. Lastly, I collected data using stimulated recall interviews (see Appendix 2D) and artefacts as data gathering techniques to improve this study's quality. Qualitative research requires that multiple data sources be used to provide a holistic and well-rounded understanding of the phenomenon under study (Denzin & Lincoln, 2011; Merriam & Tisdel, 2016; Yin, 2014). I collected data within two semesters in 2019. As explained in the following sections, I used different data gathering sources to ascertain how beliefs and goals influence novice physical sciences teachers' IBI practices.

4.6.1 Pedagogy of Science Teaching Test (POSTT)

I used POSTT, developed by Cobern et al. (2014), to collect data about the overarching goals of novice physical sciences teachers. POSTT is freely available at http://www.wmich.edu/science/inquiry-items/ and is a collection of vignettes, or cases, of teaching scenarios that specify an instructional goal particular grade level across the domains of science (i.e., Biology, Natural Sciences, and Physical Sciences). The instrument is provided with responses classified into four main orientations: didactic direct, active direct, guided inquiry, and open inquiry. Each item begins with a short-titled vignette representing an actual instructional situation for a particular topic. The POSTT has 43 science items. Out of 43 items, I selected four physical sciences cases (two for physics and chemistry) because my focus was on physical sciences teaching. I chose topics that are covered in CAPS for FET Physical Sciences.

Moreover, Ramnarain and Schuster (2014), science education researchers, established the appropriateness of the POSTT items for the South African curriculum. The vignettes specify instructional aim and grade level. I modified the vignettes by contextualising and making them relevant to the SA context. For example, instead of using K – 12, I used grades 10, 11, or 12. The second part of the modification is when I included two questions, asking novice physical sciences teachers to explain why they selected this particular instructional strategy over the other three options. I also requested that they add clarifying information that they think will help me better understand their response. Asking for an explanation was done so the novice sciences teachers could justify their answers to their chosen preferences for the POSTT questionnaire.

The purpose of POSTT was to probe thinking about overarching goals novice physical sciences teachers hold for teaching and learning. In chapter two, section 2.3.4, I explained that science teaching orientations were explored as overarching goals in this study since multiple actions must be undertaken to pursue them (Hutner & Markman, 2017). For instance, a teacher who holds a didactic direct orientation has the goal of transmitting the facts of science, as explained by Magnusson et al. (1999). In Table 2.2, chapter two, I described these four goals with their instructional characteristics. The questions about possible instruction choices for each case or vignette assisted in identifying novice physical sciences teachers' overarching goals. My approach to using POSTT to identify novice physical sciences teachers' goals was to avoid simply asking them their overarching goals but revealing these goals from their thinking through their desired IBI. Their choice of pedagogical goal would reflect their desire to teach using that particular instruction. I modified the POSTT by adding an open-ended response question for each vignette to elicit rationales for their instructional decisions. I asked them to explain why they chose a particular instruction and add information that would help me as a researcher to understand their choice. Their response to this open-ended question also assisted me in identifying their beliefs about IBI.

Teaching scenarios are valuable and efficient methods for capturing teachers' beliefs and conceptions about inquiry teaching and learning (Borg, 2012; Cobern et al., 2014; Kang, 2008). Borg (2012) suggests that studying teacher orientations presents challenges since they are not directly observable. Guven et al. (2019); Nhlengethwa et al. (2020); Ladachart (2019); Nyirenda (2019); Ramnarain & Schuster (2014); Sizer et al. (2021); Ward (2016) are among the researchers that have used POSTT in exploring and examining science teachers' inquiry orientations.

4.6.2 Teacher beliefs questionnaire (TBI)

I used TBI developed by Luft and Roehrig (2007) to elicit novice physical sciences teachers' beliefs (mediating representations) about teaching and learning. TBI is a semi-structured interview protocol that provides access to teachers' thinking and allows the participants to reveal the complexity of their belief systems. The TBI collects data on the teachers' epistemological beliefs about science teaching and learning. It has seven semi-structured interview questions (Luft & Roehrig, 2007). I used the TBI developed by Luft and Roehrig (2007) with permission from the Electronic Journal of Science Education. I used TBI as a pen-and-paper interview. After piloting the instrument, I modified the number of questions and used five instead of seven. I explained the reasons for excluding the two questions under the section of the pilot study. In this study, the purpose of TBI was to answer part of the first research question about novice physical sciences teachers' beliefs. The format of the TBI enabled me to explore the novice physical sciences teachers' thinking that observations or other methods cannot capture. Even though the TBI instrument statements are not implicitly about IBI, they encompass broader learner-centred or teacher-centred science teaching and learning ideas. Research into teachers' beliefs generally involves two main orientations: teacher-centred (i.e., traditional) and learner-centred (i.e., constructivist) beliefs (Belo et al., 2014; Luft & Roehrig, 2007).

TBI is a recommended instrument that allows the researchers to capture teachers' thinking about their beliefs, which other methods cannot. Ekiz-Kiran and Boz (2020), Fletcher and Luft (2011), Pilitsis and Duncan (2012), Wong and Luft (2015) have used TBI to capture teachers' beliefs about science teaching and learning. In addition, the TBI was most appropriate for determining novice physical sciences beliefs since Luft and Roehrig (2007) established the validity of the TBI. Validity and generalisability were established for the TBI by Luft and Roehrig (2007). Luft and Roehrig piloted the initial TBI with ten beginning secondary science teachers for validity. The second phase involved analysing interview transcripts from 75 beginning and secondary science teachers from one state. The final stage of the development of the TBI included the analysis of over 40 interviews of pre-service, induction, and experienced teachers in three different states. The final stage led to the final TBI of seven questions formally connected to different epistemological domains in science teaching (Luft & Roehrig, 2007). For the generalisability of the TBI to other content area teachers, the TBI was used with pre-service mathematics teachers. The responses provided by the pre-service mathematics teachers were different than those given by pre-service science teachers, which result supported the validity of the TBI for science teachers. 'The Cronbach alpha coefficient for the internal consistencies survey was calculated at 0.70' (Luft & Roehrig, 2007). Reliability was established for the interview process using multiple interviewers and comparisons among the data collected from each interviewer.

4.6.3 Teaching goals inventory (TGI)

To determine novice physical sciences teachers' goals for their teaching, I used the TGI questionnaire adapted from Angelo and Cross (1993). The TGI uses a horizontal numeric scale which consists of the following five choices: 1 = not applicable, 2 = unimportant, 3 = important, 4 = very important, and 5 = essential. The questions are arranged in six groups devised to help cluster common goals. The six emerging themes are higher-order thinking skills (HOTS), basic academic success skills (BASS), discipline-specific knowledge and skills (DSKS), liberal arts and academic values (LAAV), work and career preparation (WCP), and personal development (PD). The last question asks the respondent to choose one of the six statements that best describes their primary role.

One of the primary purposes of TGI is to assist teachers in understanding their teaching style and determining their teaching goals. According to Angelo and Cross (1993), identifying the teaching goals can help ensure that they align with your lesson objectives and assessment. I used TGI to answer research question one, understanding novice physical sciences teachers' mid-level and specific goals. However, I modified the TGI questionnaire, using four instead of six goals clusters that I regarded as IBI's primary (broad) goals. I excluded the liberal arts, academic values, and personal development clusters. Each goal cluster (i.e., primary goal) has specific goals which differ in numbers. Instead of 52 goals for six clusters, I ended up with 33 specific goals from four clusters. In my view, the 33 goals I selected aligned with IBI. The goal cluster became intermediate (mid-level) goals. I also added part B to the questionnaire, which had open-ended questions.

TGI is an instrument that has proven to be very useful at the higher education level. Although TGI was developed and validated for use with higher education faculty, the goals were considered very similar and suitable to the ones applicable to a middle school classroom (Bohrer et al., 2007). TGI is a well-researched tool that allowed me to determine what goals novice physical sciences teachers intend to accomplish during their teaching. Angelo and Cross (1993) computed alpha coefficients to test each goal cluster's reliability and internal consistency in the TGI. The internal consistency of the goal clusters was estimated with Cronbach's alpha coefficients of .71 or higher in all goal clusters (Angelo & Cross, 1993). Bohrer et al. (2007), Dames (2012), Shaffer et al. (2019), Fitzmaurice (2010, and Ulosevich (2016) used the TGI to examine teaching goals in higher education and middle schools.

4.6.4 Classroom observations.

I used the Electronic Quality of Inquiry Protocol (EQUIP) instrument designed by Marshall et al. (2010) for classroom observations. EQUIP is a reliable and valid instrument used to measure the quality and quantity of IBI (Marshall & Horton, 2011). However, I used EQUIP to measure the quality, not the quantity of IBI. I wanted a comprehensive qualitative analysis of the various aspects of inquiry-aligned instruction used by novice physical sciences teachers. I focused on the level at which teachers enacted IBI in the lesson and did not quantify their classroom practices. I selected EQUIP because it aligned with POSTT and TBI. For example, EQUIP provides the categories of pre-inquiry, developing inquiry, proficient inquiry, and exemplary inquiry to rate the level of inquiry in an observed lesson. POSTT utilises didactic direct, active direct, guided inquiry, and open inquiry categories. The definitions of the instruction practices between these categories are compatible. First, EQUIP was used to evaluate the level of inquiry according to the type of activities observed during the lesson.

EQUIP has four factors: instructional, discourse, assessment, and curriculum. Each factor has five constructs except for the curriculum factor, which has four. In total, there are 19 constructs. For each construct, there is one of four options that define the quality and quantity of inquiry practices: Level 1 (Pre-Inquiry) – no inquiry present; Level 2 (Developing Inquiry) – more confirmatory but beginning components of inquiry seen; Level 3 (Proficient Inquiry) – effective inquiry-based instruction has been facilitated; and Level 4 (Exemplary Inquiry). I, therefore, obtained the level of IBI measured for each lesson using the observational rating scale supplemented by these additional observations.

As mentioned earlier in this chapter, classroom observations provided a first-hand account of how novice physical sciences teachers enact IBI in their classrooms. According to Merriam and Tisdel (2016), one of the advantages of classroom observation is that it occurs in a natural setting, which in this study is novice physical sciences teachers' classroom. Furthermore, it allowed me a first-hand encounter with novice physical sciences teachers' classroom practices of IBI rather than what they wrote in the questionnaires. I used EQUIP to collect data from classroom observations which offered insight into research question two. I needed to observe novice physical sciences teachers' classroom practices to establish their relationship to beliefs and goals. Classroom observations also serve as a springboard for stimulated recall interviews regarding beliefs and goals for their IBI practices.

EQUIP is a valid and reliable classroom observation tool that provides both quantitative and qualitative descriptors of inquiry practices in the classroom context. Marshall et al. (2010) established its validity and reliability during the 2-year development of EQUIP. Ramnarain and Rudzirai (2020) and Long and Bae (2018) used EQUIP to explore and examine science teachers' classroom practices in their studies.

4.6.5 The interviews

According to Merriam and Tisdell (2016), interviews permit a researcher to understand a phenomenon from participants which is not readily observed. In this study, I used stimulated recall interviews (SRI). SRI usually uses video or audio recordings of the participants in the action, which they are later shown to use as a prompt on which to reflect. SRI is an effective technique for exploring teachers' thoughts and actions (behaviour) as it allows participants to explain their decision-making. In this study, SRI allowed novice physical sciences teachers to verbalise their thoughts on their beliefs and goals about IBI. It also allowed me to see the classroom practices through the teachers' eyes when explaining their inquiry-based practices during a classroom observation. Most research studies recommend using video-stimulated recall interviews to elicit instructional and classroom practices. Video stimulated recall has an advantage since it uses both vision and sound to recall classroom practices. However, I used audio recordings as a stimulus to recall teachers' classroom practices for this study. The purpose of SRI was to gain insight into the expressed beliefs and goals expressed in the questionnaires and during classroom practices. Questions used in the interview focused on concretising some of the remarkable issues that became evident from the questionnaires and in the course of the classroom observations. I had a list of pre-determined questions as an interview guide to be covered. However, I had great flexibility to follow certain aspects and adapt the interview protocol for each novice teacher, focusing on their beliefs and goals about IBI practices. For example, novice teachers were teaching different topics during different lessons. I asked different questions about the lessons' goals for different classroom observations. The interview focused on novice teachers' beliefs, goals, and classroom practices for lessons I observed and those I did not observe.

The most crucial purpose was to determine the reasons behind their actions during classroom observations and specific goals for their lessons. It was a powerful technique to understand teachers' actions about IBI and relate to beliefs and goals. Being a two-way conversation, SRI allowed for flexibility to obtain rich data on teacher cognition about IBI through one-on-one conversation (Cohen et al., 2018). Interviews, particularly those using open-ended questions, have been demonstrated to be an effective and crucial method to elicit science teacher beliefs (Luft & Roehrig, 2007). Table 4.2 presents the data sources summary I used to explore each research question and the analytic and theoretical framework(s) I used to analyse them. Section 4.9 gives a detailed description of data analysis.

Table 4.2

Overview of data gathering and analysis

Research question	Data source	Data produced	Analytical & theoretical frameworks
What beliefs and goals do novice physical sciences teachers hold about IBI?	POSTT TBI TGI SRI	Overarching goals Teaching & learning beliefs Primary & specific goals	TBI Constructivism theory
How do novice physical sciences teachers' beliefs and goals relate to their IBI practice?	EQUIP SRI	IBI practices	Goal-driven teacher cognition Constructivism theory
Why do novice physical sciences teachers' beliefs and goals relate to their IBI practices in the manner that they do?	POSTT TBI TGI EQUIP SRI		Constructivism theory Goal-driven teacher cognition

4.7 The Pilot study

The pilot study's purpose was to trial and refine all research instruments before the data gathering period. According to Yin (2014), conducting a pilot study helped determine any flaws, limitations, or weaknesses in the research instruments and make necessary revisions before implementing the study. The pilot study was conducted with two novice physical sciences teachers who were not involved in the study. Teachers involved in the pilot study had BEd qualifications in physical sciences and mathematics teaching. These teachers had three years of experience teaching physical sciences and were my ex-students. I chose them because their schools were easily accessible and thus convenient. Both teachers were Black African males.

I asked them if they would be willing to participate in my pilot study, explained the purpose and the procedures of my research, and why it was vital for me to do a pilot study. Both participants were keen and agreed to be part of the pilot study. The ethical procedures were followed, with each given a consent form and assured of their anonymity and confidentiality. They signed the consent form agreeing to data gathering producers, including classroom observations and interviews that will be audio recorded.

The first data gathering phase started with completing the POSTT questionnaire I collected after two days. I then gave them TBI to complete on the same collection day and informed them that it would be collected. On the third visit, I gave them TGI, which I collected on the same day. After analysing all questionnaires, I realised that participants understood instructions on how to complete them. I did not affect any changes with POSTT. With TBI, I noticed that participants deviated from answering some of the questions and gave the same responses to different questions. So, I have to rephrase the questions to make the differences apparent to the participants. I also modified the instrument and excluded two questions. The first question was, how do you decide what to teach and what not to teach? The second question was, how do you decide when to move on to a new topic in your class? My focus on teacher beliefs was teaching and learning, not the curriculum. The focus of these questions was extended to include the curriculum. In TGI, I decided to leave two clusters, liberal arts, and academic values, and personal development. These goal clusters were not related to the middle school classroom and IBI. I decided that the four clusters: higher-order thinking skills (HOTS), basic academic success skills (BASS), discipline-specific knowledge and skills (DSKS), and work and career preparation (WCP), will be able to reveal the goals that novice teachers pursue.

I conducted three classroom observations with these two teachers. I wanted to observe them while they were teaching physical sciences using IBI. Each visit was pre-arranged. Each lesson observation lasted between 55 to 60 minutes, depending on the duration of the school lesson periods. The lessons were audio recorded. I sat at the back of the classroom and took field notes and audio-recorded the lesson quietly, without becoming involved in the practices of the teacher and learners. After the first classroom observation with one of the teachers, I decided to use the observation schedule to write notes about the teacher's quality of IBI. I chose the EQUIP instrument as an observation schedule. The observation schedule was helpful, and I collected information about the teachers' IBI. I continued to take field notes, describing what was happening during the lesson, for example, during the stage where the teacher was doing a demonstration, and no one was talking. Piloting interviews provided a rich experience in conducting interviews and how to probe for further clarification. Even though I had a semi-structured interview schedule, I had to ask questions based on their responses to the questionnaires and what transpires during classroom observations. I noticed that these two novice teachers did not remember their classroom actions when I asked questions. Therefore, I opted to use stimulated recall interviews for the main study.

4.8 Data gathering procedure

The data gathering process took the same steps as in the pilot study. I was acquainted with the novice physical sciences teachers who participated in my study. I emailed them to explain my research and why I was interested in them being my participants. I explained how the data would be gathered. Their responses indicated that they were willing to participate. I then arranged for the first meeting to meet the teacher and the school principal in person and explain my research. On the same day of the visit, I left the consent letters for both to read and sign. I explained the consent letters, reassuring them that their identity would be confidential. My classroom observations will not negatively impact the smooth running of the school, and those findings will not have a negative effect on their professional development. I also informed them of their right to withdraw from the study at any time before data analysis had begun. I informed them that I would come the following day to collect consent letters to get the chance to reflect on them. I came the next day to collect the consent letters and asked them to make copies for their record keeping.

The first phase of gathering data started with completing the POSTT questionnaire I collected after two days. I gave them the TBI to complete on the same collection day and informed them that it would be collected. On the third visit, I gave them TGI, which I collected on the same day. I requested the teachers draw a classroom observation schedule with suitable dates and times for my second school visit. I collected the plans when I was collecting the TGI questionnaire. During the whole process of data gathering, I had informal conversations with novice physical sciences teachers. These conversations were brief because we would talk in the staff room or when going to class. I wrote essential conversations in my journal for future reference during analysis.

Non-participatory observation methods captured the classroom practices of novice physical sciences teachers. ‘The non-participant observer is an outsider who sits on the periphery or some advantageous place (i.e., the back of the classroom) to watch and record the phenomenon under study (Creswell, 2005, p.212). Though it was impossible to be invisible in the classroom, I tried to be discreet as possible. I sat on the periphery of the classroom and took field notes and audio-recorded the lesson quietly, without becoming involved in the practice of the teacher and learners. The lessons were audio-recorded because I thought it would not cause much disturbance to both the teacher and learners as much as video recording. I decided to use small digital voice recorders and placed them in different positions in the venue and one on the table or desk I was using.

I visited each novice physical sciences teacher for a minimum of four lessons to observe, take field notes, and audio record the lesson. I decided to undertake a minimum of four, not three, as in the pilot study. I increased the number of lesson observations with the aim of getting the overall general impression of the novice physical sciences teacher's IBI practices. Each lesson was about 40 to 60 minutes, depending on the school timetable. All classroom observation visits were pre-arranged with the teachers. I had a well-developed plan for school visits that avoided clashes. In cases where classes were cancelled in the school, the novice physical sciences teacher would contact me by WhatsApp message or email to let me know and arrange for the new class schedule. I focused almost exclusively on classroom instructional practices. During these classroom observations, I concentrated on the IBI classroom practices component of the novice physical sciences teachers' orientations by observing their actions, activities, questioning strategies, and using resources. As explained in section 4.6.1, I used EQUIP classroom observation protocol to get a comprehensive qualitative analysis of the various aspects of IBI used by novice physical sciences teachers. At the end of each lesson observation, I collected the artefacts, i.e., lesson plans, hand-outs, and worksheets, for that particular lesson. Denzil and Lincoln (2018) and Merriam (2009) suggest that no single piece of data is substantial for drawing a conclusion. I collected these artefacts to contribute to the enrichment of data triangulation during analysis.

The lesson observations also helped develop probing questions I later used with the novice physical sciences teachers' interviews to further understand their beliefs and goals about IBI. To supplement my notes, I also collected a sample of all physical artefacts, including lesson plans, hand-outs, practical tasks, and tests the teachers referred to or distributed to learners for each lesson I observed. I also supplemented my note-taking by voice recording all the classroom sessions to help fill in anything I may have missed. Lastly, I had informal conversations with the teacher after the lesson when I needed clarity on any aspect of the instruction. Informal conservations were not recorded, but I wrote about important issues in my research journal. I used classroom observations, which allowed me to compare teachers' classroom practices with beliefs and goals about IBI expressed during questionnaires.

I conducted face-to-face SRI with novice physical sciences teachers to understand their body language and ease their responses to the questions. I conducted one SRI after observing four classroom practices for each teacher. I had already gained insight into their beliefs and goals from the questionnaires. The questions I asked focused on their beliefs and goals for their classroom practices. To triangulate data, I asked a question: in the POSTT questionnaire, you indicated that you used guided inquiry most of the time, so why did you choose it? For classroom practices, I referred to a particular behaviour and played a segment of the video-recorded lesson to stimulate their thinking and to reflect upon instructional actions.

My professional relationship and warm, friendly rapport with the teachers helped ensure that the interview was a social, interpersonal encounter and not merely a data gathering exercise. We agreed on the day and time to conduct the interview. The interviews were conducted after teachers were done with mid-year examination invigilation and marking. All interviews took place on school premises, in a quiet, private classroom, since learners were in recess. Interviews were audio-taped and transcribed verbatim and offered to novice physical sciences teachers for review and member checking. Member checking allows for clarification and validation of information transcribed by the researcher and is integral to constructing a trustworthy research design (Creswell, 2013). Member checking also serves as a form of triangulation; by asking participants to look over interview transcripts, analytical thoughts, and drafts of the final report (Creswell, 2013), the researcher ensures that the participants' ideas and thoughts are represented appropriately. Table 4.3 provides the timeframe when data sources were administered.

Table 4.3

Data gathering timeline during the Year 2019

	TBI	POSTT	TGI	L1	L2	L3	L4	SRI
Nelisa	22 April	25 April	30 April	27 June (school holidays)		28 June	2 July	15 October
Amalia	22 April	25 April	30 April	3 May	09 May	20 May	17 June	12 August
Wayde	22 April	25 April	30 April	15 May	24 May	5 June	12 June	13 August
Gatsha	22 April	25 April	30 April	21 May	22 May	17 July	18 July	18 August

4.9 Data analysis

The process of data gathering and analysis occurred simultaneously. According to Merriam and Tisdell (2016), data analysis aims to find answers to derived research questions. I used manual coding with the assistance of Microsoft Word Office. MS Word was well-suited for the three questionnaires (i.e., TBI, POSTT, and TGI), EQUIP and SRI. In this study, I opted to use the Framework Analysis developed by two qualitative researchers, Ritchie and Spencer (1994), to analyse each case (Srivastava & Thomson, 2009). I analysed each case separately and then did a cross-case analysis.

The general approach to Framework Analysis is inductive in nature, but it allows for the inclusion of both known and emergent themes. Framework Analysis shares many of the common features of thematic analysis. However, framework analysis's advantage is that it provides systematic and visible stages to the analysis process to clarify the stages by which the results have been obtained from the data (Ritchie & Spencer, 1994; Srivastava & Thomson, 2009). Framework Analysis involves five steps: familiarization, identifying a thematic framework, indexing, charting, and mapping and interpretation (Ritchie & Spencer, 1994; Srivastava & Thomson, 2009). I followed these steps to analyse each novice physical sciences teacher's beliefs and goals about IBI practices.

Familiarisation. This first stage refers to the process during which the researcher becomes familiarised with the transcripts and gains an overview of the collected data (Ritchie & Spencer, 1994; Srivastava & Thomson, 2009). During the familiarisation stage, I began with data organising. The data from the questionnaires was already in the text but hand-written. I typed the responses from the questionnaires for easy reading and citing. I listened to all data sources from audio recordings (i.e., classroom observations and SRI), digitised, transcribed, and saved them for data analysis. I organised data labelling the transcripts using novice physical sciences pseudonym names. I became immersed in the data by reading the texts and listening to audio recordings. This process occurred throughout the data gathering phase.

Identifying a thematic framework. This is the process of developing the initial coding framework both from a priori issues and from emerging issues from the familiarisation stage (Ritchie & Spencer, 1994; Srivastava & Thomson, 2009). I analysed the TBI (pen and paper interview) as the thematic framework using the analytical rubric designed by Luft and Roehrig

(2007). I classified the codes into categorical themes for each of the five questions that Luft and Roehrig (2007) developed. The themes were:

- Traditional: Focus on information, transmission, structure, or sources
- Instructive: Focus on providing experiences, teacher-focus, or teacher decision
- Transitional: Focus on teacher/learner relationships, subjective decisions, or affective response
- Responsive: Focus on collaboration, feedback, or knowledge development
- Reform-based**:** Focus on mediating learner knowledge or interactions.

I coded each novice physical sciences teacher's responses to one of the five themes for each question. Traditional and instructive responses represent teacher-centred beliefs, while responsive and reform-based responses represent learner-centred beliefs. Transitional responses include both teacher and learner beliefs.

In the analysis of POSTT, I used the responses provided with the instrument to establish if novice physical sciences teachers could identify the correct pedagogical orientation that matches the instruction. There were four pedagogical orientations: didactic direct, active direct, guided inquiry, and open inquiry. I considered that they understand the difference between the four instructions if they match all four or three to their pedagogical orientations. In addition, novice physical sciences teachers' POSTT choices of pedagogical orientation were indicators of their specific overarching goal.

I used TGI to identify primary goals (i.e., clusters) and specific goals. I calculated the mean rating for each cluster. I considered the cluster(s) with the highest mean rating as the primary goals teachers pursue. I considered the chosen goals essential under the cluster with the highest rating (ticked '5') to be the teachers' specific goals. Table 4.4 indicates how I calculated the mean rating to determine the primary goal.

Table 4.4

Primary goal mean rating

CLUSTER		Goals in a cluster	Number of goals	Percentage rated 'Essential'	Mean Rating
HIGH-ORDER THINKING SKILLS	(HOTS)	1 – 8	8	100	5.0
BASIC ACADEMIC SUCCESS SKILLS	(BASS)	9 – 17	9	11	2.7
DISCIPLINE-SPECIFIC KNOWLEDGE & SKILLS	(DSKS)	18 – 25	8	11	2,7
WORK AND CAREER PREPARATION SKILLS	(WCPS)	26 – 33	8	13	2,8

SRI. I analysed the SRI along the dimensions of TBI and POSTT thematic frameworks. For beliefs, I looked for statements coded in the TBI framework. I looked for: 'My goal for teaching is…' or 'I want my learners to …' as the statements to classify them as goals.

EQUIP. I used the thematic framework from the EQUIP (Marshall et al., 2010) observation schedule to code the level of inquiry used from classroom observations. As explained in the section for data sources, EQUIP has four factors, instructional, discourse, assessment, and curriculum, that I used as themes and their descriptive coding. It also places the teacher on the inquiry continuum to determine the level of inquiry. I rated the level of IBI for each theme using EQUIP, from Pre-inquiry (Level 1) to Developing Inquiry (Level 2) to Proficient Inquiry (Level 3) to Exemplary Inquiry (Level 4) in each lesson. For each lesson, I had a teacher IBI summative level rating, i.e., level 3-proficient inquiry. I then averaged the summative level ratings for each lesson to determine the overall teacher IBI level.

Indexing or coding involves applying the thematic framework to the data, using numerical or textual codes to identify specific pieces of data which correspond to differing themes (Srivastava & Thomson, 2009). Firstly, I coded the TBI data. I identified statements and key phrases using the analytical rubric revealing the specific belief. For example, I coded a statement or a phrase as traditional if it indicated teacher-centred teaching and learning. I coded comments as instructive when the phrase focuses on the teacher as the primary source of knowledge but when some attention is given to learners' participation. Even though the teacher saw her role as teacher-centred, phrases that illustrate concern for learners' engagement were coded as transitional. I coded phrases as responsive when the main focus was on learners' construction of knowledge, and the teacher played a more minimal role as a mediator of opportunities. I did not get any phrase that can be coded as reformed-based. After coding each question, I displayed beliefs in a profile table summarising all captured data. Secondly, I coded data from the POSTT. I identified their individual choices of pedagogical orientation to each case as their overarching goal. For example, I regarded a teacher who chose guided inquiry for all or three cases as pursuing an inquiry goal. For the analysis of the second part, where I asked novice physical sciences teachers to explain why they selected this particular instructional strategy over the other three options, I used the themes and coding developed for TBI. For example, I coded the responses that focused on the transmission of knowledge and teacher-centred as traditional. I triangulated the coding from part B with the coding on TBI.

I used the coding guide from EQUIP framework for the classroom practices. I rated the level for instructional factor for five constructs when: the teacher predominantly lectured to cover content (instructional strategies); the teacher explained concepts and learners did not explore the concept (order of instruction); the teacher was the centre of the lesson and rarely acted as a facilitator (teacher role); learners were consistently passive as learners, taking notes, practicing on their own (learner role); and the learners focused solely on mastery of facts, information (knowledge acquisition). The summative rating for the instructional factor was level one (i.e., pre-inquiry) from the above example. I followed the same coding procedure for all the factors.

Charting requires the development of graphical displays to represent the thematic framework of the data collected. I created thematic charts for novice physical sciences teachers' beliefs. Tables 4.5 and 4.6 indicate the examples of thematic charts I developed from TBI and EQUIP, respectively. The detailed thematic charts for each novice teacher were discussed in the following four chapters. Figure 4.2 is the goal hierarchy I developed from POSTT and TGI questionnaires.

Table 4.5

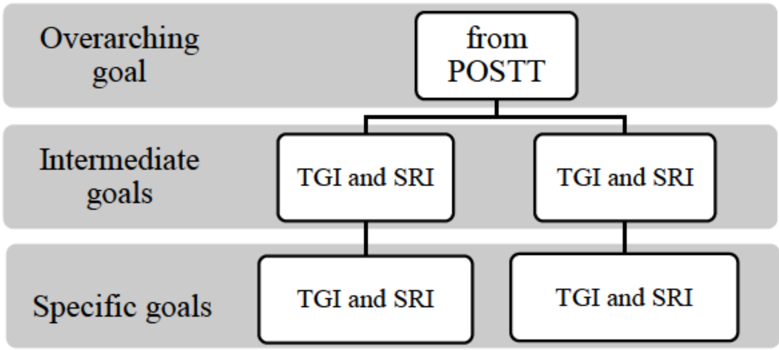
Teaching and learning beliefs

QUESTION	RESULTS	REASON FOR CHOICE
HOW DO YOU DESCRIBE YOUR ROLE AS A TEACHER?	Responsive	- a facilitator of learning

I compiled each novice physical sciences teacher's goal hierarchy as indicated in figure 4.2. The overarching goals were analysed from POSTT. The primary (mid-level) and specific goals were analysed from TGI and SRI.

Figure 4.2

Teachers' goal hierarchy



I created the charts for each lesson after classroom observation. I will rate the level for each construct under each factor and then average for a total level rating. Table 4.6 shows the chart I ended up with for the final EQUIP ratings.

Table 4.6

EQUIP ratings

Factors	*Instructional*	*Discourse*	*Assessment*	*Curriculum*	*Overall IBI*
Level	3	3	3	3	3 - Proficient

I compiled the above graphical representation for each novice physical sciences teacher of their beliefs and goals about IBI to their classroom practices.

Mapping and interpretation involve searching for patterns and synthesizing charts and graphical displays into narrative accounts (Ritchie & Spencer, 1994). I used Table 2.4 from chapter two for mapping and interpretation, which provided the alignment of teachers' beliefs, goals, and IBI practices. I created a descriptive write-up for each case by identifying novice physical sciences teachers' beliefs, goals, and classroom practices. I presented each case separately as I opted for multiple case study (Yin, 2017). Chapters five to eight presented the result of this analysis. I studied these four cases individually to provide more extensive descriptions and explanations of novice physical sciences teachers' cognition.

4.10 Trustworthiness

Trustworthiness is the related term used in qualitative research as a measure of the quality of research. Trustworthiness in a research study addresses the issues of credibility, transferability, dependability, and confirmability to ensure that the research was undertaken rigorously and the findings are authentic (Guba & Lincoln, 1985). They further posit that trustworthiness is established when findings reflect the meanings precisely described by the participants. I assured the trustworthiness of the data by adhering to the abovementioned criteria.

Credibility is the degree to which the research results represent the participants' actual meanings. Creswell (2013) considered credibility as an attempt to assess the accuracy of the findings as best described by the researcher and the participants through extensive time spent in the field, the thick, detailed description, and the closeness of the researcher to participants in the study. I ensured credibility in this study through triangulation, prolonged engagement, and member checking. According to Creswell (2013, p. 259), triangulation is the process of corroborating evidence from different individuals (e.g., a principal and a student), types of data (e.g., observational fieldnotes and interviews), or methods of data gathering (e.g., documents and interviews) in descriptions and themes in qualitative research. For triangulation, I used multiple data sources to ascertain evidence explaining the relationship between novice physical sciences teachers' beliefs and goals to IBI practices. I used three different questionnaires (TBI, POSTT, TGI) on novice physical sciences teachers' beliefs and goals about IBI. I used EQUIP to rate IBI practices. SRI was used to gain insight into novice physical sciences teachers' beliefs and goals to their IBI practices. Moreover, I spent a satisfactory amount of time in the field before and during lesson observations for prolonged participant engagement. I had a prior relationship with the novice physical sciences teachers, so I built the relationship with the school principals, including mathematics and science HOD, for easy access during lesson observation. I conducted classroom observations on several occasions.

Furthermore, to enhance the credibility of this study, I adhere to member checking. Member checking is a process in which the researcher takes the data and tentative interpretations back to the participants and asks if they will check the accuracy of the account (Creswell, 2013; Merriam, 2009). I enhanced member checking by visiting the novice teachers to ensure my transcriptions' accuracy and allow them to verify my interpretations gathered during the data gathering and analysis process. It was important for me to share their EQUIP classroom observation scoring for IBI. Even though member checking has its own disadvantages, Lincoln and Guba (1985) consider member checking into the findings the most critical technique for establishing credibility.

Transferability. Transferability is analogous to external validity, that is, the extent to which findings can be generalized (Mirriam, 2009). However, generalisation cannot occur in qualitative research. As a result, transferability is considered a challenge in qualitative research. Merriam and Tisdell (2016) suggested that providing an adequate description of the research context allows readers to assess the similarity of their situations to the study context. I did not assume generalisation but increased the study's transferability by giving a detailed description of each novice teacher. I provided thick descriptions by providing detailed findings supported by several novice teachers' quotes from the questionnaires, interviews, and classroom observations. I also collected extensive information about novice physical sciences teachers and their research settings, which are more likely to help readers apply transferability.

Mirriam (2009) suggested maximum variation as another strategy for enhancing transferability. According to Mirriam, maximum variation is 'purposefully seeking variation or diversity in sample selection to allow for a greater range of application of the findings by consumers of the research' (p. 229). Even though the focus was on novice physical sciences teachers, I enhanced transferability by purposely selecting them from different school contexts. Furthermore, Yin (2014) posited that applying multiple cases can increase transferability. I used multiple case studies in this study, considering each novice teacher's context, beliefs, and goals to maximise transferability.

Dependability. Merriam (2009) referred to dependability as the extent to which research findings can be replicated with similar subjects in a similar context. On the contrary, Lincoln and Guba (1985) described dependability as whether or not the findings can be replicated but whether they are consistent with the data collected. The research process enhances the study's dependability by auditing (i.e., audit trail). Lincoln and Guba (1985) and Merriam (2009) conceptualised a research audit trail describing how data were collected, how categories were derived, and how decisions were made throughout the study as one engages in analysis and interpretation. In this study, I used a detailed description of the methodology and data gathering instruments to follow the research process to attain dependability. The individual case reports had evidence of the participants' responses from questionnaires, classroom observations, and SRI.

Merriam (2009) suggested the peer-review technique: discussions with colleagues regarding the study process, the congruency of emerging findings with the raw data, and tentative interpretations to enhance dependability. I presented the study process and tentative findings to my colleagues in our science research cohort. The discussions during the research cohorts improved my study arguments and analysis. Additionally, my two supervisors contributed to my research process and allowed me to build a strong argument for my research findings.

Confirmability. According to Creswell and Poth (2018), both dependability and confirmability are established through auditing the research process. Lincoln and Guba (1985, p.290) addressed the confirmability criteria through the question, 'Are the findings a product of participants' responses and not the researcher's biases, motivations, interests, or perspectives?' To enhance confirmability, I continue the research auditing process and am transparent with the research report. I kept a research journal to document the informal conversation with novice teachers, especially after classroom observation. I also recorded the environmental factors from the school context when visiting novice teachers.

Another technique to enhance confirmability is the researcher's position or reflexivity. Mirriam (2009, p. 229) refers to the researcher's position or reflexivity as critical self-reflection regarding assumptions, worldview, biases, theoretical orientation, and relationship to the study that may affect the investigation. In this study, I declared my relationship with novice physical sciences teachers as my undergraduate students. I also explained my philosophical stance, which influenced the research process of choosing the topic, methodology, data analyses and interpretation, findings, and conclusions.

4.12 Ethical consideration

To a large extent, the trustworthiness of a study depends upon the researcher's ethics when conducting research (Merriam, 2009). As the researcher, I interacted intensely with novice physical sciences teachers, thus entering their personal domains. Therefore, appropriate steps should be taken to adhere to strict ethical guidelines in order to uphold participants' privacy, confidentiality, dignity, rights, and anonymity. I also considered that ethical issues occur in different phases of the research process, such as before conducting the study, at the beginning of the study, during data gathering, conducting data analysis, reporting the data, and publishing a study.

Prior to conducting the study, I addressed the issue of gaining access. Negotiating access refers to ethical considerations of the permission needed to gain access to schools (Creswell & Poth, 2018). I needed a gatekeeper's letter to gain access to the schools where novice physical sciences teachers worked. The first step in negotiating access was to obtain permission to conduct research in the schools around Durban from the KwaZulu-Natal Department of Basic Education. Permission was granted with the requirement I will meet before commencing with data gathering in schools (See Appendix 1A). The second step was to apply for ethical clearance with the University of KwaZulu-Natal Human Research Ethics Committee. The university's responsibility is to ensure that research on human participants is ethical and respects the participants' rights (See Appendix 1B). I needed to ensure I did not compromise ethical standards by adhering to the requirements as stated in the letters.

At the beginning of the study, I implemented the procedure to obtain informed consent. Informed consent was sought from the novice physical sciences teachers and the school principal. Informed consent ensured that novice teachers participated voluntarily and were treated fairly. With the principals, I ensured that I respected the norms of the schools. Each teacher received a letter with full details of the research process, which they were required to sign. I informed them of the purpose and role of the study and invited them to participate. I provided a clear description of their role in the data gathering process. I informed them of their right to withdraw at any point during the study. This discussion assisted novice teachers in making an informed decision before signing the consent letters.

During the data analysing and reporting stage, I ensured that I adhered to confidentiality and anonymity. According to Cohen et al. (2018), researchers should protect the individual privacy of participants and exclude any identifying information from the research. Novice physical sciences teachers had a right to privacy, so their confidentiality was highly prioritized. I gave each participant a pseudonym to ensure their confidentiality. The focus of the study was on novice physical sciences teachers, so I just mentioned the schools without using their names. I used appropriate security measures and stored all written questionnaires, lesson observation schedules, and audio files in the university's safely locked cabinet to maintain confidentiality.

4.13 The chapter summary

This chapter has provided an overview of the research design and methodology of the study. It described and justified the choice of the social constructivism paradigm, qualitative approach, and a multiple-case study design. The data gathering techniques, i.e., open-ended questionnaires, classroom observation, and SRI, enabled me to capture IBI's beliefs, goals, and classroom practices to determine the relationship between these mental constructs. The data gathering plan and data analysis methods are described in detail. Lastly, the issues of trustworthiness, enhanced through the research study's credibility, transferability, dependability, and confirmability, were argued and justified. The following four chapters, five, six, seven, and eight, present data presentation for four cases.

CHAPTER FIVE
DATA PRESENTATION - CASE STUDY ONE: NELISA

5.1 Introduction

The purpose of this study was to explore the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices to understand how beliefs and goals influence practices. The study addressed the question: *What is the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices?* In the previous chapter, I discussed the research design and methodology employed in this study. The study adopted a qualitative research design and a multiple-case involving four novice physical sciences teachers. Data were collected using open-ended questionnaires, classroom observation, and stimulated recall interviews. In this chapter, I present the findings as explained below.

In the following four chapters, I comprehensively describe each novice physical sciences teacher in his/her own context. Each case description in chapters five, six, seven, and eight began with an introduction to their background and the schools in which they work. The profile description was based on researcher observation, informal communication, interview, and the participant's school website.

For each case, the data presentation provided under the heading beliefs and goals about IBI addressed question one, of the study:

> What beliefs and goals do novice physical sciences teachers hold about IBI?

Under the heading Teacher beliefs and goals in relation to IBI practices, I addressed research question two:

> How do novice physical sciences teachers' beliefs and goals relate to their IBI practices?

Lastly, research question three:

> Why do novice physical sciences teachers' beliefs and goals relate to their IBI practices in the manner that they do,

is addressed under the heading, The influences on teacher beliefs, goals, and IBI practices.

5.2 Background and context

Personal background. At the time of the study, Nelisa[5], a Black African female, was 25 years old with four years of teaching experience. She held a Bachelor of Education (BEd) degree with a specialisation in physical sciences and mathematics education. She studied towards her Bachelor of honours (BEd Hons) degree in Mathematics and Science Education for professional development. She was teaching physical sciences in grades 10, 11, and 12. She was passionate about teaching physical sciences and wanted to open the world up for her learners. Explaining what excites her about teaching physical sciences, she said:

> when I see my learners excited, enjoying, and relating what we were learning about in real life. When I hear them saying, ' …ohh this is why this is happening…or this is how this is happening…'. I can see that they connect with the content because the problem is when they are learning most of the time. They cannot feel why they are learning about this. Still, the moment they can relate to that, it is exciting and shows that they understand the nature of physical sciences while learning about environmental technology. So, it is exciting when they connect the content to everyday life situations (SRI, 15 October 2019).

Nelisa wanted to teach physical sciences for relevance and for learners to connect what they learn in class to everyday life situations.

School setting. She was teaching in a public secondary school situated in a township. The school was from grades 8 to 12, with an enrolment of 1886 mixed-raced learners-70% Black African, 19% Indians, 11% Coloured, and 59 teachers. Learners came from the surrounding nearby townships. The community served by the school had a high percentage of middle to low-income earners. The school had two science laboratories for NS (grades 8-9) and physical sciences (grades 10-12).

Classroom setting. Nelisa had 40 learners in her grade 12 physical sciences class. Nelisa's classroom can be regarded as overcrowded as the teacher-learner ratio is 1:35. Her grade 12 learners were the only class studying physical sciences in the school. One can assume that her classroom comprises a heterogeneous mix of learners regarding their intellectual abilities. She taught all her physical sciences lessons in the laboratory, even where no practicals were

[5] All participants had a pseudonym

conducted. Learners sat on the lab stools in the middle of the laboratory and faced the chalkboard during the discussion. There were tables with a sink and tap where learners stood when doing the experiments along the wall. During my visits, I observed that the classroom (i.e., laboratory) was clean and orderly, with posters displayed on the wall of physical sciences (chemistry and physics). The school had essential laboratory equipment and chemicals required for physical sciences learning.

5.3 Teacher beliefs and goals about IBI

Nelisa's teaching and learning beliefs. Data analysis from TBI revealed that Nelisa's beliefs were categorised as **responsive,** according to Luft and Roehrig's (2007) coding protocol. The responsive beliefs category indicated that Nelisa held learner-centred beliefs about teaching and learning. Below, I provide evidence of further analysis of TBI that supports responsive beliefs with sample responses for each question.

Nelisa's beliefs about the teacher's role. Nelisa's response regarding her teaching role demonstrated that she held responsive beliefs. Responding to how she described her role as a teacher, Nelisa explained, 'I play the role of being a facilitator rather than always being in the front explaining. I move around a lot to either individuals or groups to guide, answer, correct, question or explain depending on their relevant need' (TBI, 22 April 2019). She perceived being a learning facilitator as a teacher who maintains collaboration between herself and learners. Nelisa supported her response during SRI as she described her role as:

> a tutor or facilitator, a person who does more helping, mostly individually instead of lecturing in the front. I usually teach less, allowing learners to be more independent and search for themselves. Instead of always explaining, I guide them, so I typically view my role in physical sciences as a facilitator (SRI, 15 October 2019).

Nelisa's above response illuminated her role as a physical sciences teacher that guides learners to meaningful learning by allowing them to be responsible for their learning by finding information on their own.

Moreover, Nelisa revealed responsive beliefs about her role as a learning facilitator when responding to why she chose guided inquiry in the POSTT questionnaire. She expressed a response that showed her consideration of learners' prior knowledge. She explained that she 'would not want her learners to feel like empty vessels that need to be fed or feel like the lesson is boring like didactic direct instruction. Learners have prior knowledge of the content linked to the new lesson' (POSTT, 25 April 2019). Nelisa considered eliciting learners' prior knowledge to serve important pedagogical purposes of increasing understanding of physical sciences content and making IBI effective. Nelisa further elaborated, describing the importance of eliciting learners' prior knowledge:

> I would not like to undermine the fact that they have prior knowledge and just deliver the new knowledge, such as didactic or active direct. So, I am more of finding the balance between what they already know and trying to guide them to what they do not know and share their previous experiences to connect them to new knowledge (POSTT, 25 April 2019).

Not only did Nelisa demonstrate the importance of learning by building on what learners already know, but she also demonstrated that knowledge needs to be connected to new knowledge. Nelisa's statements above (i.e., TBI, SRI, and POSTT) reflect learner-centred beliefs in the teacher's role. Nelisa had learner-centred, responsive beliefs rooted in the teacher as interactive and a negotiator. She used her position as a facilitator to respond to learners as unique individuals responsible for their own learning, collaborative learning, and mediating learners' prior knowledge to uncover what they know.

Nelisa's beliefs about maximising learning. Nelisa demonstrated responsive beliefs, responding to how she maximised learning in her classroom. She described:

> through small group work. I allow learners to engage with peers so that they are more comfortable with reading or doing particular tasks. I usually observe that when I walk around, even those that generally do not understand can hear and understand their peers better. Peer explaining is also learning; they must organise their thoughts when explaining and making sense (TBI, 22 April 2019).

Nelisa's primary focus in the above statements was on learners' interaction with her as a teacher but mostly with peers to maximise physical sciences learning. Nelisa reflected learner-centred beliefs as she responded on designing a positive classroom environment that focuses on and allows learners to interact with each other. She also considered learners as unique individuals with different learning capabilities. For example, some learners comprehend by listening to the teacher and other learners and practicing.

Nelisa's beliefs about how learning is occurring. Nelisa's response to how the learning happened in her physical sciences classroom was coded responsive. She indicated that she moved around in the classroom and 'gave individual attention to learners who needed help' (TBI, 22 April 2019). Elaborating on her response, she explained how they learn:

> I give many tasks because we do a lot of past question papers or exam-like activities from the books. I trust that practice makes perfect, so the more problem-solving questions they engage with, the more capable they can tackle new problems. I move around and provide the suitable needs noted above per each learner. Learners will work together and help each other solve problems because I cannot waste time focused on one problem for the whole class. Also, learners would have different problem-solving issues (TBI, 22 April 2019).

Nelisa's response reflected learner-learner (i.e., peers) and teacher-learner interaction. Even though she initiated the interaction, she believed in learners working together to solve problems and sharing ideas to support each other in the learning process. Nelisa's belief is categorised as learner-centred as it emphasises learners' active participation, conducting discussion, and exchanging opinions as an indication of their learning.

Nelisa's beliefs about learners' understanding of concepts. Nelisa revealed transitional beliefs when responding to how she ascertains the learners' understanding of physical sciences concepts. She explained that she made observations 'through facial expressions or physical gestures. For example, when learners nod, place fingers on chin and ask follow-up questions' (TBI, 22 April 2019). She further elaborated:

> When I hear the sound 'oooooh!!!!! Kanti isiyamasha' (oooooh…this is easy). I know they have learned something. My grade 12 learners would let me demonstrate to them, and if they did not understand, they would shout 'ay mam ayimashi' (slang for, no madam, it is not going right). Thus, when learning takes place, I would hear them shout to me or each other, 'iyamasha ke manje' (slang for, It is going right now). Therefore, I would also know they learned it when they provided correct answers and reasoning (TBI, 22 April 2019).

Nelisa's response focused on the visual cue of learners where learners get excited and show that through their reaction or facial expression. Nelisa's belief was neither learner nor teacher-centred.

Nelisa's beliefs about how learners learn science best. Nelisa's response to how learners learn physical sciences best revealed responsive beliefs. In her response, she explained how she interacts with her learners or learners interact with each other to explain the concepts of the physical sciences. She works with learners who complete activities with understanding to help the other learners struggling with the same activity during her lessons. She referred to these learners as 'teacher assistance.' This is how Nelisa explained the role played by 'teacher assistance' in her class:

> They are team players. They understand that I do less teaching most of the time and expect them to engage with the work and work with each other. Even those who may work alone, once they finish, I usually first check their work and ask them to help me, so some learners play the role of being teacher assistants (TBI, 22 April 2019).

Nelisa's response focused on learners interacting with each other, explaining and interpreting the physical sciences' content. Each learner is given a chance and allowed to share ideas. Nelisa held learner-centred beliefs that promote collaborative learning when learners discuss physical sciences concepts, sharing their ideas using their own words; this is an indication that they have learned and internalized the topic.

Summary of Nelisa's teaching and learning beliefs. Table 5.1 profiles the overview of Nelisa's beliefs about physical sciences teaching and learning, which were coded overall as responsive. The emphasis on responsive beliefs is on learner-centred learning, learners developing investigations, conceptual understanding, depth over breadth, teacher as facilitator, learning together, and learning to modify existing ideas.

Table 5.1

Summary of Nelisa's teaching and learning beliefs

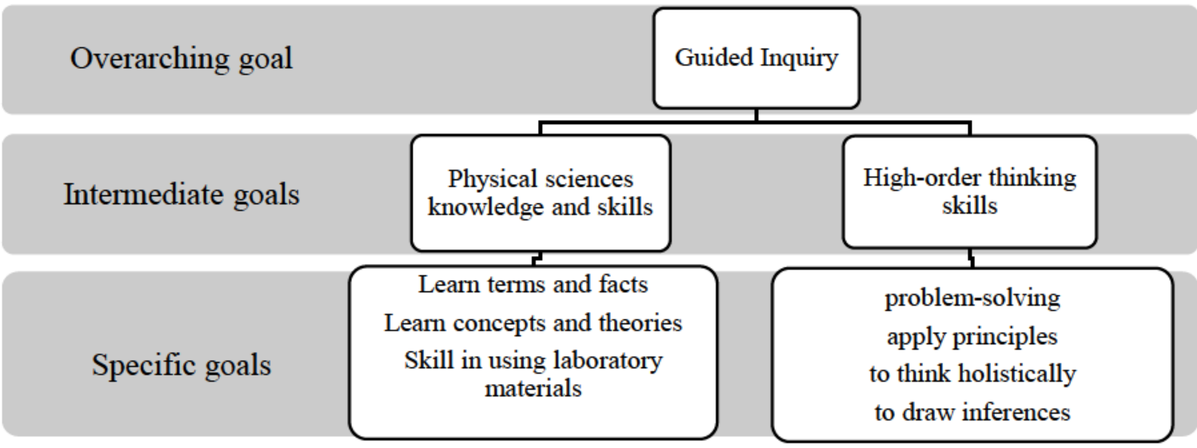
	QUESTIONS	RESULTS	REASON FOR CHOICE
TEACHING BELIEFS	How do you describe your role as a teacher?	Responsive	- I am the facilitator of learning - encourages learners to take charge of their learning - uses collaborative learning - considers learners' prior knowledge
	How do you maximise learning for your learners?	Responsive	- learners interact with her and with each other - learners as unique individuals
LEARNING BELIEFS	How do you know when learning is occurring in your class?	Responsive	- learners helping each other in problem-solving activities
	How do you know your learners understand?	Transitional	- learners get excited - learners nod their heads - learners ask follow-up questions
	How do your learners learn science best?	Responsive	- learners working together to interpret the content

From the above analysis and viewing beliefs as a system, I described Nelisa as having learner-centred beliefs consistent with a constructivist approach to teaching and learning. Firstly, she believed in her teaching role as collaborator, facilitator, and tutor. Her beliefs about teaching were that teachers should create a learning environment where learners are engaged in constructing knowledge. Secondly, she believed that learning occurs when learners are in charge of learning and ownership of their knowledge. Her classroom practices focused on creating an active learning environment through collaborative learning. Finally, she believed in authentic knowledge application and problem-solving.

Nelisa's goal system. Nelisa's goal system was developed and hierarchically arranged from her responses in POSTT (25 April 2019), TGI (30 April 2019), and SRI (15 October 2019). Figure 5.1 indicates a streamlined hierarchical arrangement of Nelisa's goals. Nelisa's goals existed in a hierarchy with different levels of abstraction. The specific goals at the lowest level and the overarching (i.e., abstract) goal at the highest level. In between, there were two intermediate goals. Below, I detailed the analysis of each goal with sample responses.

Figure 5.1

Nelisa's goal system



Nelisa's overarching goal. Nelisa adopted guided inquiry as her overarching goal for teaching and learning physical sciences (POSTT, 25 April 2019). Nelisa had knowledge about the other goals (i.e., didactic direct, active direct, and open inquiry) as revealed by POSTT analysis, and she reflected a desire to use guided inquiry. The four case study scenarios revealed that she desired to use guided inquiry and regarded this as her main goal. Explaining what guided inquiry can accomplish for her learners, she emphasised the following points:

> My main goal for using guided inquiry is that I expect my learners to be independent and ask questions, make sure that they understand concepts correctly, and avoid misconceptions. I would not like to undermine them. I allow them to share their previous experiences so that they can connect them to new knowledge. So guided inquiry appears as the balance between all four instructions (SRI, 15 October 2019).

Nelisa desired to teach physical sciences through guided inquiry for three reasons: learners to be independent, ask questions and understand physical sciences concepts. Nelisa perceived guided inquiry to develop independent learners.

Nelisa's intermediate goals. Analysis of TGI and SRI revealed two major (i.e., mid-level) goals for Nelisa. The first goal with the highest mean rating score was to 'help learners develop physical sciences' knowledge and skills.' The second goal was to 'help learners develop high-order thinking skills' (TGI, 30 April 2019). Analysis of TGI revealed that Nelisa considered these goals essential because she aimed to have learners accomplish them in physical sciences teaching and learning. Nelisa also mentioned these goals when asked about her teaching goals for physical sciences during the SRI. She commented:

> I hope they (learners) will gain knowledge, understanding, and skills to enter careers such as pharmacy, doctors and engineering, and more. I want to prepare my learners for future careers (SRI, 15 October 2019).

Nelisa's response emphasised the goal of developing learners' knowledge and skills she chose in the TGI. However, Nelisa coupled the goal of developing physical sciences knowledge and skills with the goal of work and career preparation. She wanted her learners to have 'successful careers and fulfilling personal lives' (SRI, 15 October 2019). She indicated a commitment to her learners and their future learning.

The second intermediate goal with a high mean rating score was to 'help learners develop high-order thinking skills' (TGI, 30 April 2019). Nelisa believed that IBI engages learners in deeper, thoughtful interactions, which will assist with the development of high-order thinking skills. Nelisa explained the goal of high-order thinking skills as:

> Thus they (learners) will learn investigative skills, hypotheses, and evaluation to develop or emphasize laws/principles. I think this is important to learn critical skills and justify their thoughts or actions (TGI, 30 April 2019).

Pursuing this goal for Nelisa was essential because she 'expected learners to ask questions, have curiosity, and infer' (TGI, 30 April 2019). Nelisa wanted her learners to be independent thinkers and apply their knowledge while thinking critically.

Nelisa's specific goals. Nelisa revealed several specific goals that she rated essential in teaching and learning physical sciences. Those specific goals were from the two clusters selected as mid-level goals. Under the goal to develop physical sciences knowledge and skills, the specific goals were to 'learn terms and facts, learn concepts and theories, and skill in using laboratory materials' (TGI, 30 April 2019). Under the goal of developing high-order thinking skills, the specific goals were problem-solving, applying principles, thinking holistically, and drawing inferences (TGI, 30 April 2019). However, when asked to justify her classroom actions during the SRI, Nelisa revealed the specific goals she pursued during each lesson. For example, learners conducted an acid-base titration investigation during lessons one and two. Nelisa explained her actions and the specific goal she was pursuing in this lesson:

> for learners to be familiar with the apparatus and the laboratory work method because, in the examination, one or two questions ask about the laboratory activities. So, I needed them to be familiar with dependent variables, independent variables, graphs, and observations (SRI, 15 October 2019).

Nelisa was pursuing the specific goal for learners to be equipped with skills in using laboratory materials, simultaneously developing content knowledge so that learners can answer questions during examinations. Elaborating on her specific goals for lessons one and two, to include the construction of content knowledge, she explained:

> If they (learners) conducted this experiment, they would understand the titration process and the acid, base, and endpoint. Instead of just teaching theory, they would be able to relate the theory to the practical. Since the main goal was for them to understand how to do titration calculations but this time around, they will not just do calculations alone. They can still relate the practical activities to the content knowledge (SRI, 15 October 2019).

Nelisa's specific goals for the above lessons were the same and reinforced the specific goals for lesson four. Nelisa offered the following explanation for her actions for the satisfaction of the goal for lesson four, current electricity:

> to assist learners in the construction of knowledge and skills. For learners to answer basic questions about electrical circuits and emf, just to know the vocabulary like potential difference, resistance was more like an introduction. Still, at the same

> time, they must be able to tackle questions. Learners must be able to think. They must be familiar with the terms and how to answer questions (SRI, 15 October 2019).

In the above quote, Nelisa emphasises the specific goals of learning physical sciences terms and facts and concepts and theories.

Summary of Nelisa's goals. The goals within Nelisa's case goal system were reinforcing. The progress towards maintaining the overarching goal resulted in the satisfaction of the intermediate and specific goals. For example, Nelisa's specific goal of developing learners' laboratory skills was to support mid-level goals of knowledge and skill, which supported the overarching goal for guided inquiry. Nelisa's intermediate goals, to develop knowledge and skills and high-order thinking skills, were independent of each other. Developing high-order thinking skills was an intermediate goal in Nelisa's goal representations that she chose in the TGI but did not explicitly express during the SRI through specific goals. However, this goal manifested in her classroom practices during the four lessons. Nelisa encouraged high-order thinking skills like problem-solving and critical thinking for her learners. However, she did not identify any specific goals related to it. Some of the inquiry skills that were displayed during her lessons were for learners to be able to: develop hypotheses, work collaboratively, form coherent arguments, understand how things relate to the real world, and critique experiment design. The developed process skills included drawing conclusions, observation, classification, and comparisons. She wanted learners to draw inferences from the data observed and be able to apply the laws in solving problems. Learners' other skills include searching for information, scientific reasoning, and explaining concepts and laws scientifically.

5.4 Teacher beliefs and goals in relation to IBI practices

The above discussion revealed Nelisa's learner-centred beliefs and goals she pursued during classroom practices. Classroom practice findings were necessary to see how her beliefs and goals relate to her actions. In the following section, I firstly describe data analysis for Nelisa's classroom practice ratings. Nelisa's IBI classroom practices were rated using the EQUIP by Marshall et al. (2010). The EQUIP ratings will be followed by data analysis of Nelisa's mediating and goal representations in relation to her classroom practices. The EQUIP qualitative analysis was based on four-lesson observations: **Lessons One and Two** (This was a double lesson that took place over 2,5 hours): Acid-Base Titration; **Lesson Three**: Acid-Base titration calculations and **Lesson Four:** Current electricity. Then, below the classroom practices discussion, I provide data analysis responding to research question two on the relationship between beliefs and goals to classroom practices.

Classroom practices

Instructional factor. Nelisa was rated overall at the proficient inquiry, with most constructs at level 3 for the instructional factor. Table 5.2 tabulates the rating for each construct under the instructional factor.

Table 5.2

Nelisa's EQUIP ratings: Instruction

Factors associated with IBI	Construct	Lessons 1 & 2	Lesson 3	Lesson 4
Instructional factor	Instructional Strategies	3	3	2
	Order of Instruction	3	2	3
	Teacher Role	3	3	3
	Learners' role	3	3	3
	Knowledge acquisition	2	3	2
Overall		**3**	**3**	**2.5**

A rating at level three indicated that Nelisa's classroom practices were learner-centred, as she occasionally lectured in all four lessons observed. Nelisa engaged learners in the investigations, question and answer, group discussion, problem-solving, etc., that developed the concepts' knowledge and understanding. She involved the learners in an investigation that provided opportunities for learners to construct knowledge before the content was explained in lessons one, two, and four. Her order of instruction allowed learners to explore the concepts before explaining or discussing them. For example, in lessons one and two, she introduced the lesson by asking learners to predict if it was possible to determine the unknown concentration of acid if the concentration of the base is known. She stated the lesson objectives and allowed learners to explore the concept of titration. Nelisa's order of instruction helped her to be a guide and facilitator during her teaching. In all four lessons observed, Nelisa consistently acted as a facilitator and guided her learners to develop physical sciences knowledge and skills. Learners actively worked in small groups during lessons one and two, investigating, predicting, hypothesising, and sharing ideas.

There was a lot of interaction between learners since they were working in groups. The noise level was from learners working together respectfully. Nelisa promoted communication between herself and learners and between learners themselves. Even during lesson three, acid-base titration calculations, which continued the previous lesson based on the knowledge of concepts and skills in solving problems related to the concepts, learners were actively engaged in meaningful learning. During lessons one and two, learners focused on developing the sciences skills in performing an investigation. For lessons three and four, the focus was on explaining and elaborating through the application of concepts, mastery of facts, and problem-solving. In all four lessons, Nelisa remained at level three because she showed evidence of being a skilled facilitator who effectively engaged her learners in the development of process and understanding.

Discourse factor. Nelisa's summative rating was at level three for the discourse factor, which is the classroom environment that supports IBI. Table 5.3 provides the rating for the discourse factor.

Table 5.3

Nelisa's EQUIP ratings: Discourse

Factors associated with IBI	Construct	Lessons 1 & 2	Lesson 3	Lesson 4
Discourse factor	Questioning level	3	3	3
	Complexity of questions	3	3	2
	Questioning ecology	3	3	3
	Communication pattern	3	3	3
	Classroom interaction	3	3	3
Overall		**3**	**3**	**3**

Level three rating reflects learner-centred practices where learners engage with questioning that challenges their thinking. Nelisa used all types of questioning levels in her teaching, and learners also prompted the communication. During lesson four, on current and potential difference presentation, Nelisa emphasised asking interpretational questions even though some of her problem-solving questions involved routine application. She provided learners an opportunity to think and discuss the questions before responding and often asked learners to explain their thinking or give reasons for their answers during her teaching. Nelisa promoted communication between herself and learners and between learners themselves. She engaged learners in a discussion by asking questions and answers. Nelisa and the learners communicated during the lessons, with some learners' questions guiding the discussion. Learners were free to ask questions during the lesson. The same interaction was observed in the other lessons, where learners could compare their experiment results with other groups and discuss their findings. She remained at the proficient inquiry for all the lessons as she promoted classroom interaction, conversational communication, and the use of open-ended questions.

Assessment factor. Nelisa was rated at the proficient inquiry, level three for assessment factors associated with IBI, with one indicator rated at level one, developing inquiry. Table 5.4 provides the EQUIP rating for the assessment factor.

Table 5.4

Nelisa's EQUIP ratings: Assessment

Factors associated with IBI	Construct	Lessons 1 & 2	Lesson 3	Lesson 4
Assessment factor	Prior Knowledge	3	2	3
	Conceptual Development	3	3	3
	Learner Reflection	2	1	1
	Assessment Type	3	3	3
	Role of Assessing	3	3	3
Overall		**3**	**2,5**	**3**

During the lesson introduction, Nelisa engaged learners by eliciting their prior knowledge to link it to the new concept she wanted to introduce. For example, she assessed learners' prior knowledge using question and answer as a strategy. She would systematically ask questions in an attempt to identify misconceptions or activate some learners' prior knowledge. She utilised questioning to scaffold learning, assess learners' prior knowledge, and challenge learners to interact with science content for conceptual development from lower to higher cognitive levels. She introduced the lesson by asking about the importance of electricity usage and how it has influenced their lifestyle. She asked these questions to capture their interest and link her topic to learners' everyday life experiences. Nelisa was rated minimal for learners reflecting on the learning process. She did not encourage learners to reflect, but her actions implicitly encouraged reflection. Nelisa used learners' responses to ask follow-up questions, clarifying concepts on learners' thinking. She scored level three in all the lessons as she integrated assessment throughout the lessons and encouraged learners to think at higher levels.

Curriculum factor. Nelisa's summative rating was at level three (i.e., proficient inquiry) with all four indicators in the curriculum factor. Table 5.5 provides a curriculum factor rating for all four lessons.

Table 5.5

Nelisa's EQUIP ratings: Curriculum

Factors associated with IBI	Construct	Lessons 1 & 2	Lesson 3	Lesson 4
Curriculum factors	Content depth	3	3	3
	Learner Centrality	3	3	3
	Integration of Content and Inquiry.	3	3	3
	Organizing & Recording of Information	3	3	3
Overall		**3**	**3**	**3**

The activities in all four lessons provided learners with an opportunity to be active and engage in an investigation. Lessons one and two used inquiry to address the content of acid-base titrations. The level three score for content depth is justified because Nelisa had her learners use what they learned from the investigations and connect to a bigger picture. For example, during lessons one, two, and four, learners used their knowledge to explain the application of acid and base titration experiment and electricity in everyday life experiences. Nelisa did not merely teach physical sciences facts but also the basic principles or problem-solving strategies for approaching different problems. Nelisa's lessons one, two, and four allowed for some flexibility during learners' investigation. Small groups of learners explored and built knowledge by manipulating materials linking the investigations to the concepts of acids and bases and electric circuits. Lesson three provided conceptual understanding as learners could link the concepts to everyday life examples.

Classroom practices summary: Using EQUIP instrument, Nelisa's IBI classroom practices overall rating was at level three, i.e., proficient inquiry level for all the constructs (instruction, discourse, assessment, and curriculum) as indicated in Table 5.6.

Table 5.6

Nelisa EQUIP ratings

IBI factor	*Instructional*	*Discourse*	*Assessment*	*Curriculum*	*Overall IBI*
Level	3	3	3	3	3 - Proficient

Proficient inquiry is characterised by constructivist classroom practices that are learner-directed. Nelisa was a facilitator and encouraged conceptual understanding, depth over breadth, learning together, and learning as a modification of existing ideas. Nelisa had a consistent level three rating in all the lessons with no movement to increase or decrease.

Nelisa's teaching and learning beliefs and IBI practices. Section 5.3 detailed Nelisa's teaching and learning beliefs that were identified as responsive. In Section 5.4 under classroom practices, Nelisa was rated as having level three, proficient inquiry instruction. This section revealed if the teaching and learning beliefs and goals stated by Nelisa were related to her classroom practices.

Nelisa believed that the role of the teacher was to be a facilitator. During classroom observations, I observed her role as a facilitator of learning. She occasionally lectured, and learners were active and engaged in activities (i.e., acid-base titration experiment, solving problems, and ohms law experiment). She emphasised collaboration between learners. She was available moving around to different groups and also collaborating with learners. She created a relaxed working environment for her learners. Working in the laboratory motivated learners to take charge of their learning because they looked for different apparatus and asked permission to use them.

Nelisa allowed her learners to work with peers. She believed that learning could be maximised by allowing learners to work in small groups and share information. I observed Nelisa's learners working in small groups during lessons one, two, and four. They were sharing information and predicting the results of the experiments. During lesson three, they solved problems in groups, defending their approach when there were different opinions. During these four lessons, learners developed process skills and the application of learned content in everyday life situations.

Nelisa had responsive beliefs about determining when learning is occurring in her class. She believed that learning occurs when learners interact with each other within the groups explaining their results or how they had solved the problem. I observed Nelisa moving into different groups to listen to learners' discussions. She would facilitate the discussion in other groups by challenging the group's reasoning in solving the problem. That group would have an opportunity to defend their reasoning before the teacher.

Nelisa's response revealed transitional beliefs on determining learners' understanding of physical sciences concepts. Her response was basically on learners' visual cues, i.e., happy facial expressions, nodding their heads, and laughing, saying the content is straightforward. During classroom observation, I noticed that although Nelisa's beliefs were transitional, they leaned toward responsive beliefs. During lesson three, one learner asked about using Gaviscon medicine when having heartburn. One learner from the other group responded to the question by explaining the acid-base neutralisation process in the stomach. This scenario indicated that learners were not only asking about the content of acids and bases but also its application to new knowledge, which was a real-life situation.

Nelisa believed that learners learn science best when they behave like team players. She believed in herself as a coach, doing less teaching and allowing learners to work independently. I observed Nelisa encouraging collaboration with her learners. She would ask those learners that like to work alone to join other groups and participate in group discussions.

Nelisa's goal system and IBI practices. Again, section 5.3 gave an account of Nelisa's goal system. Nelisa attributed the specific goals for lessons one, two, and four to developing physical sciences knowledge and skills. I observed the learning of terms, concepts, facts, and theories during the lessons. During lessons one and two, learners discussed and differentiated between strong and weak, diluted and undiluted acids and bases. During lesson four, they stated and discussed ohms' law. They conducted an acid-base titration experiment and ohms law experiment to develop science process skills. These specific goals reinforce the intermediate goal of developing physical science knowledge and skills. During lesson three, they applied the neutralisation principle and solved problems.

Furthermore, Nelisa adopted an overarching goal of using guided inquiry instruction in the teaching and learning of physical sciences. Nelisa's IBI classroom practices overall rating was at level three, (i.e., proficient inquiry level). Nelisa maintained the goal of using guided inquiry through the satisfaction of specific goals during classroom practices. Therefore, the direct relationship (i.e., alignment) between Nelisa's actions and goals was observed through the specific goals during classroom practices.

In summary, I observed Nelisa manifesting teaching and learning beliefs system about learner-centred instruction, her role as the facilitator of learning, the role of learners in active participation and being responsible for their learning, and the importance of investigation and collaboration during classroom practices. These beliefs acted not in isolation but as a system. There was a direct relationship between what Nelisa stated she believed and her classroom practices. The same relationship was observed between Nelisa's professed goals and classroom practices.

5.5 The influences on teacher beliefs, goals, and IBI practices

This section provides a synthesised analysis that combines the findings from Nelisa's teaching and learning beliefs and goals that guided her classroom practices.

Beliefs and goals. The above findings revealed that Nelisa held learner-centred teaching and learning beliefs and adopted a guided inquiry goal. I have shown in section 5.4 that Nelisa's teaching and learning beliefs were directly related to her IBI practices. Her classroom actions played an essential role in the goals she pursued during classroom practices. Nelisa's teaching and learning beliefs and guided-inquiry based goals dominated her thinking and appeared to drive her classroom practices. When I asked her to reflect on her actions and understand why she used a particular activity, for example, investigation, to engage learners in learning, she responded with statements indicating what she desired to accomplish, i.e., the desired outcome for her learners. For example, she said, 'I am hoping that they will gain knowledge and understanding and skills' and 'I expect my learners to be independent (see the section on goals) (SRI, 15 October 2019). She did not respond with statements that correspond to knowledge or beliefs such as 'I believe learners can learn.' These statements in her responses revealed that Nelisa's decision-making during teaching and learning was based on the selection of goals consistent with her beliefs. Moreover, Nelisa's justification of her classroom practices focused on the guided inquiry goal than the specific goals that drive her actions.

Nelisa's overarching goal was to use guided inquiry reflected during classroom practices. Supporting her choice of guided inquiry, Nelisa said, 'I would choose A (guided inquiry) because it enables the learners to construct the knowledge. I would not use B (didactic direct) and C (active direct) because they already took away the learner's curiosity' (POSTT, 25 April 2019). Concerning not using open inquiry, Nelisa said she avoided using open inquiry because she thinks it can bring many misconceptions to learners. The above responses indicated that Nelisa had knowledge of the other goals but was committed to using guided inquiry. She verbalised the reasons not to use open inquiry, didactic, and active direct. The specific goals pursued during each lesson reflected the currently active goal, the guided inquiry goal. And the currently active goals will influence the value of specific classroom approaches.

Social and physical context. It is also possible for teachers to be firmly committed to a goal such that they pursue goal satisfaction with or without regard for the ability of the environment to support such goal pursuit. There is a possibility that Nelisa had such a commitment to the guided inquiry goal. For example, Nelisa mentioned school context, curricula artefacts, physical environment, resources, and social influence as environmental factors that did not support her inquiry goal. During the interview (SRI, 15 October 2019), she commented on the school setting and said that 'teaching in a township school compared to teaching in a private or model C school will affect how I teach.' Nelisa understood the inequalities between the township and 'model C' schools and wanted to be where she could make the most difference in her learners' lives.

Besides school inequalities, Nelisa also comments about time and curriculum (syllabus). She stated:

> Because the time is too short, we have to finish the syllabus. So, the time is limited to doing exciting activities like watching the videos in class, making them interested, or capturing their interest. The syllabus is too long and the teaching time too short to do different exciting activities (SRI, 15 October 2019).

She added on curricular artefacts when asked about the curriculum material she used to teach physical sciences:

> I used the CAPS documents that gave me the curriculum to know what I should cover in the lesson. The examination guidelines guide me on how learners should answer the questions during the examination (SRI, 15 October 2019).

Nelisa's response indicates that the curriculum materials specified what and how to teach. Commenting on the role of Subject Education Specialist (SES), she said:

> So, they (SES) influence the teaching in terms of wanting the syllabus to be quickly finished so that the learners are ready for examinations, whereas the time is so short and the syllabus is so long. They would want learners to understand concepts at the same time you need to finish the syllabus, making it stressful and a lot of work. So as a teacher, you end up focusing on the most important concepts (SRI, 15 October 2019).

She indicated the pressure from SES in teaching to prepare learners for examination instead of conceptual understanding.

Nelisa mentioned the above factors that influence her teaching of physical sciences. She commented on the school context, time constraints, the prescriptive curriculum, and SES involvement in the teaching and learning of physical sciences. However, she was firmly committed to using guided inquiry besides mentioned environmental factors. She also commented on factors that support her teaching. Nelisa had resources like 'the projector for PowerPoint presentations and physical sciences app' (SRI, 15 October 2019). She was using the laboratory as a teaching and learning class. Commenting on how conducting practical work assisted her learners, she said:

> it is interesting for learners to actually see processes in reality instead of being told that if you mix this and that, this will come out. They even identify themselves as future chemical engineering or pharmacies when they wear their laboratory coats. Practical work gives them a glance at which science field to follow after finishing school. But most of all it is interesting. They verify, observe, and explore. They can explore further and design new things for themselves. They can be creative (SRI, 15 October 2019).

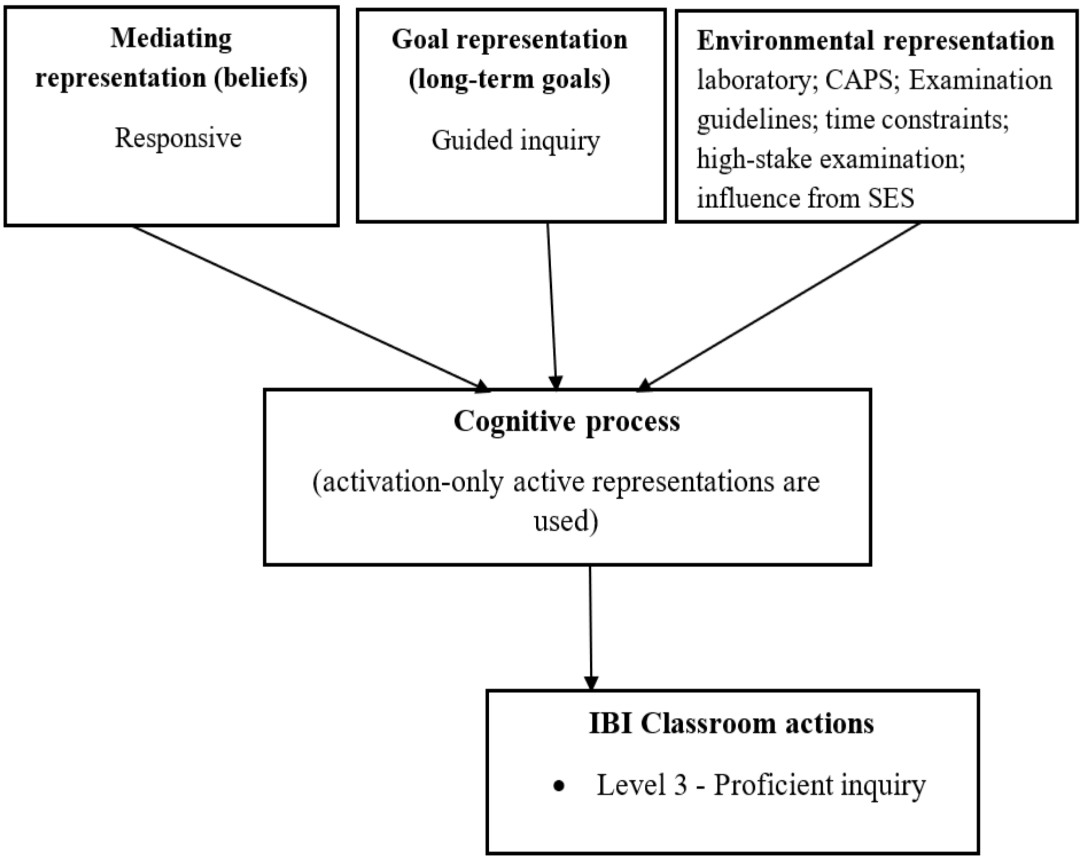
Hands-on activities supported her belief in how learners learn physical sciences and pursue the specific goal of developing laboratory skills.

5.6 Summary of findings

This chapter detailed Nelisa's teaching and learning beliefs, the goals she pursued, and the IBI level during classroom practices. Figure 5.2 summarizes Nelisa's findings, as explained in this chapter.

Figure 5.2

Nelisa's beliefs, goals, and environmental representations summary



Nelisa held responsive teaching and learning beliefs. She adopted an overarching goal of guided inquiry. The environmental factors that supported her classroom practices were teaching and learning lessons in the laboratory. She also used the CAPS documents for guidance on what to teach. However, the time and pressure from district SES constrained her teaching. The interpretation of these findings is discussed in chapter nine. The following chapter six presents the second case.

CHAPTER SIX

DATA PRESENTATION - CASE STUDY TWO: WAYDE

6.1 Introduction

This chapter presents Wayde's cases, as stated in chapter five. Firstly, I start by describing Wayde's background information and context. This discussion is followed by Wayde's teaching and learning beliefs and goals. IBI classroom practices and their relationship to teacher beliefs and goals follow this discussion. Lastly is the discussion on the observed classroom action to teacher beliefs and goals. The chapter ends with a summary of Wayde's beliefs, goals, environmental context, and IBI practices.

6.2 Background and context

Personal background. Wayde, an Indian male teacher, 28 years of age, had one year of physical sciences teaching experience during the data-gathering period. He holds a Bachelor of Education (BEd) degree specialising in physical sciences and life sciences education. He taught physical sciences in grade 11, life sciences in grade 10, and technology in grades eight and nine. He commented on the heavy workload, teaching five periods a day, and said that: 'sometimes I felt overwhelmed with the teaching I have to do daily, preparing, planning, and teaching three subjects daily is challenging. I also have to do the marking for these three subjects' (SRI, 13 August 2019). At the time of the study, he was not pursuing any studies but planned to register for BEd (honours) in mathematics and sciences the following year. Wayde stated that he loved teaching physical sciences even though it was challenging with grade 11. He was passionate about teaching and had a good relationship with his learners.

School setting. Wayde taught in a public secondary school situated in a peri-urban area. The school enrolment had 1072 learners and 43 teachers. The school had a diverse population of 30% Coloured, 65% Black African, and 5% Indian learners. The learners in the school mostly came from the local area within which the school was situated. The sciences, mathematics, and technology department had 12 teachers, and five were in physical sciences. Wayde pointed out that his school had one laboratory used by grade 12 sciences learners. The laboratory had essential equipment and the chemicals required for grades 10-12 physical sciences practicals.

However, he complained about the low maintenance in the laboratory, as some equipment was either not working or broken.

Classroom setting. Wayde had 30 learners in his grade 11 physical sciences class. The learners were seated in pairs in neat rows facing the chalkboard, and he conducted his lessons while standing at the front of the classroom. Wayde taught in a traditional, arranged classroom where learners face the chalkboard. His classroom had a cabinet mounted on the wall, which held some physical and life sciences equipment. His table was located at the front of the classroom beside the door. He mentioned that he never used the laboratory, and all his lessons were taught in the classroom. Even practical activities were conducted in the classroom since the grade 12 classroom used the laboratory. On the day of the practical activity, he will fetch equipment and chemicals from the laboratory. However, Wayde's classroom did not have enough space for safely conducting investigations.

6.3 Teacher beliefs and goals about IBI

Wayde's teaching and learning beliefs. According to Luft and Roehrig's (2007) coding protocol, Wayde's beliefs were categorised as traditional. The traditional beliefs category indicated that Wayde held teacher-centred beliefs about teaching and learning. Below, I provide further analysis of TBI that supports traditional beliefs with sample responses for each question.

Wayde's beliefs about the teacher's role. Wayde's belief about the role of a teacher was traditional. This is how Wayde explained his role as a teacher:

> I play the role of a leader while teaching physical sciences. I facilitate learning and lead learners towards the desired outcome. I question and initiate interactive learning. I also play an assessor's role, whereby I assess learners' understanding or performance during the lesson (TBI, 22 April 2019).

Elaborating on his role during the interview, Wayde expressed the same role of being a leader and explained:

> I used the role of the leader to guide learners along the right or correct path of conceptual understanding. I play the role of the facilitator as I provide support to learners and aid in their understanding. I provide background knowledge (TBI, 22 April 2019).

Even though Wayde mentioned being a facilitator in his response, he reflected on the traditional beliefs when explaining. When responding to the question about his role as a physical sciences teacher during the SRI, he responded:

> As a physical science teacher, my role is to pass on knowledge to the learners first, help them understand, facilitate their learning, and guide them in their learning process (SRI, 13 August 2019).

Wayde's responses about his role as a teacher above reflected a teacher-centred, traditional teaching belief for the following reasons. Firstly, the focus was on himself as he placed himself at the centre of knowledge and regarded himself as the centre of the teaching and learning process. Secondly, he revealed being the decision-maker of learning in the classroom. Thus, Wayde's responses are about him (i.e., I), reflecting authoritative power concerning his learners. Thirdly, he revealed himself as the one who knows the physical sciences' content and has to direct learners on what they need to know. Finally, he pointed to providing information and experience to his learners, regarding himself as a deliverer of information and an all-knowing sage.

Wayde's beliefs about maximising learning. Wayde revealed traditional beliefs about how he maximised physical sciences learning. He explained:

> I provide as much content knowledge as I can on a specific topic. I provide understandable and relative examples of ideas or content that link to everyday life and allow learners to understand better (TBI, 22 April 2019).

In the above excerpt, Wayde's response was coded traditional because it reflects all about him using different activities as a provider of information. From the above response, Wayde reflected teacher-centred, traditional beliefs about teaching. The response revealed Wayde believed in 'direct, tell and explain' instruction to maximise learning. Thus, his response showed him as the teacher who removes the responsibility of learning from learners and views himself as responsible for their learning. Moreover, he believed in providing physical sciences content in a structured manner for his learners' understanding. Finally, Wayde's beliefs were in one-way teacher-learner interaction, individual learning, not collaborative learning, and he did not mention anything about learners' interaction through small groups or peer learning.

Wayde's beliefs about how learning is occurring. Wayde held traditional beliefs about how learning occurs in his physical sciences class. Wayde's response to how he knew that learning was occurring in his classroom was:

> Learners ask questions. Learners make references that connect content with the world around them. Learners apply what they have learned to tasks given to them (TBI, 22 April 2019).

The above quote indicates that Wayde determines the learning process through learners' actions, what learners do during the instruction, and at the end of a lesson. Furthermore, Wayde focused on learners' achievements from their assessment tasks in class. Wayde's responses reflected teacher-centred beliefs that learning is based on repetition.

Wayde's beliefs about learners' understanding of concepts. Wayde's response was categorised as instructive belief. Responding to how he knows learners understand the concepts, he explained:

> Content questioning occurs when learners provide answers and pose questions surrounding topic content during a lesson's conclusion. Learners answer activities that show evidence of understanding through their different approaches (TBI, 22 April 2019).

Wayde's response is rated as an instructive belief because it focused on measuring learners' performance on assessment for knowing that they have developed an understanding of the content. According to Wayde, learners' understanding is demonstrated when they apply what they have learned to the tasks given to them. He assumed learners understand from their answers when asking questions without further prompting. In addition, Wayde reflected teacher-centred beliefs that learners' understanding is through correct answers during testing.

Wayde's beliefs about how learners learn science best. Wayde's response on how learners learn best revealed traditional beliefs. Explaining how learners learn physical sciences best, Wayde said:

> learners read from the textbook and do practices they can consolidate with themselves; if something is missing from my explanation, they can get it from the textbook. They can also ask questions to verify if there is something that they do not understand. I think that activities help learners consolidate what they have learned and assess themselves (TBI, 22 April 2019).

Wayde's response revealed teacher-centred, traditional beliefs about learning that textbooks and materials are primary resources for learning. Moreover, he wanted learners to listen while teaching and taking notes.

Summary of Wayde's teaching and learning beliefs. Table 6.1 profiles the overview of Wayde's beliefs about physical sciences teaching and learning, which were overall coded as traditional. The emphasis on traditional beliefs is on teacher-directed learning. Traditional and instructive categories emphasise beliefs that focus on teacher-centred, frontal teaching and foundational knowledge. His responses and explanation revealed that he believes physical sciences teaching and learning involve transferring teacher knowledge to learners.

Table 6.1

Summary of Wayde's teaching and learning beliefs

	QUESTION	RESULTS	REASON FOR CHOICE
TEACHING BELIEFS	How do you describe your role as a teacher?	Traditional	- I play the role of a leader - I guide learners along the right or correct path of concept understanding - I provide background knowledge
	How do you maximise learning for your learners?	Traditional	- I provide as much content knowledge - I provide understandable and relative examples of ideas or content
LEARNING BELIEFS	How do you know when learning is occurring in your class?	Traditional	- Learners apply what they have learned to tasks given to them
	How do you know your learners understand?	Instructive	- during the conclusion of a lesson, content questioning occurs, during which learners provide answers and pose questions surrounding the topic content
	How do your learners learn science best?	Traditional	- learners read from the textbook and do practices they can consolidate with themselves

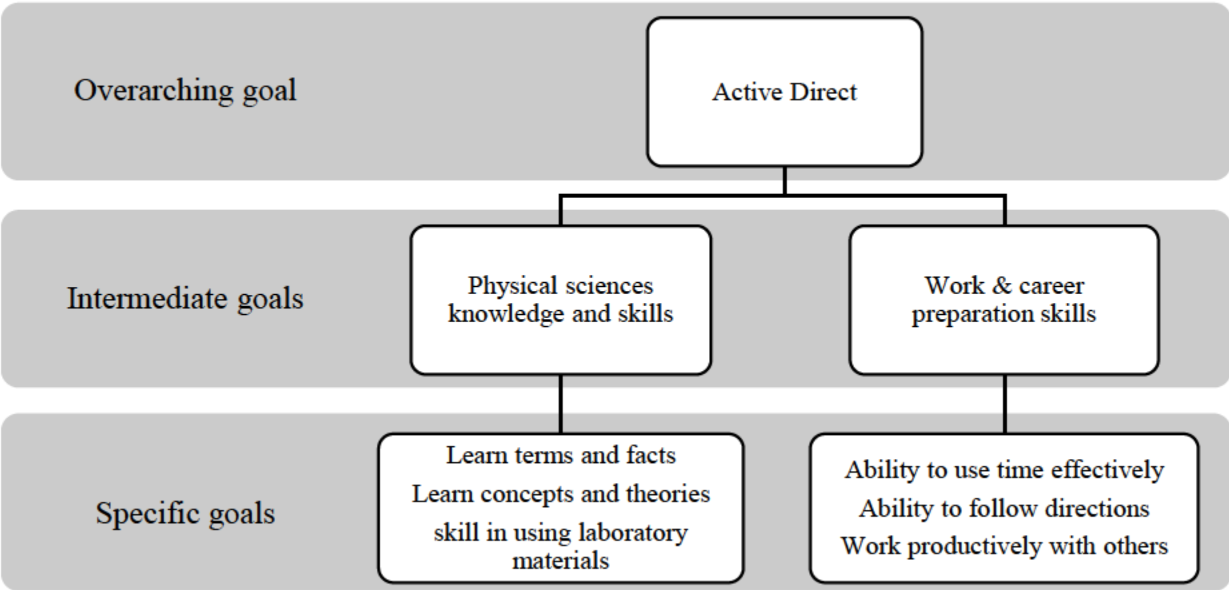
From the above analysis, I describe Wayde as having a teacher-centred belief system consistent with a traditional approach to teaching and learning. Firstly, he held traditional teaching beliefs that he is a primary source of knowledge and should deliver accurate knowledge to learners. Wayde's beliefs about his role were directive and rooted in authority. Secondly, he also held traditional beliefs about learning. He believed that learning occurs when learners are passive and receive knowledge from him. Wayde believed in controlling learning and classroom knowledge. He believed in teacher-centred classroom activities that emphasise individual work. Thirdly, Wayde believed in learners' knowledge reproduction. Finally, he believed in learners recalling facts after learning had taken place.

Wayde's goal system. Wayde's goal system was developed and hierarchically arranged from his responses in POSTT (25 April 2019), TGI (30 April 2019), and SRI (13 August 2019).

Figure 6.1 indicates a hierarchical arrangement of his goals. Wayde's goals existed in a hierarchy with different levels of abstraction. The specific goals at the lowest level and the overarching (i.e., abstract) goal at the highest level. In between, there were two intermediate goals. Below, I detailed the analysis of each goal with sample responses.

Figure 6.1

Wayde's goal system



Wayde's overarching goal. Wayde adopted the overarching (i.e., abstract) goal of using active direct teaching and learning of physical sciences (POSTT, 25 April 2019). In the four case scenarios from the POSTT, he chose active direct as the goal that drives his desired instructional strategy. Waydes' responses on POSTT revealed that he knew other goals (i.e., didactic direct, guided, and open inquiry). Explaining why his goal was to use active direct, he said:

> First, I prefer to use active direct to give learners a ground to work from, considering or comparing what guided and open inquiry can do. I think that there is more control with active direct. You can steer learners in a certain way. If there is a need to go in another direction, you can go as well (SRI, 13 August 2019).

Wayde had the desire to teach through active direct. However, his justification reflected a desire to transmit physical sciences facts and control learners. Wayde's response does not indicate his desire to involve learners in hands-on activities.

Wayde's intermediate goals. Analysis of TGI revealed two intermediate (i.e., mid-level) goals for Wayde. The first goal with the highest mean rating score was to help learners develop physical sciences knowledge and skills. The second goal was to develop learners' work and career preparation skills (TGI, 30 April 2019). Analysis of TGI revealed that Wayde considered these two goals essential because he aimed to accomplish them in physical sciences teaching and learning. Wayde supported these goals when reflecting on his teaching during SRI. Elaborating on his first goal of assisting learners in developing an understanding of physical sciences knowledge and skills, he explained:

> To allow learners or give them some kind of stand to investigate on their own, do research, learn, consolidate, and create their own understanding of what they learn in class (SRI, 13 August 2019).

According to Wayde, learners should be assisted in gaining content knowledge and developing science skills to further their education and survive in the outside world. Wayde's goal of assisting learners in developing an understanding of physical sciences emphasised being knowledgeable about the science content and its relation to the world around them.

The second intermediate goal with a high mean rating was to develop learners' work and career preparation skills. Wayde explained his goal as follows:

> I want my learners to feel that they are ready for grade 12. After that, I want to prepare them to go out to any science degree. I want them to feel good about physical science, not as a challenging subject but enjoy it (SRI, 13 August 2019).

Elaborating on this goal, Wayde stated:

> mainly is to give learners skills that they require, basic skills before they leave school so that they are better equipped when they take out science course or science degree after school and ahh, to give them a general understanding of physical sciences phenomena and how the world works around us (SRI, 13 August 2019).

According to Wayde, learners need the necessary skills to carry them to the next grade and higher education institutions. He wanted to prepare his learners for successful adulthood. Wayde coupled the goal of work and career preparation with the goal of making physical sciences an enjoyable subject for learners.

Wayde's specific goals. Wayde rated several specific goals as essential in teaching and learning physical sciences under these two mid-level goals. Under the goal of developing physical sciences' knowledge and skills, the specific goals were to 'learn terms and facts, learn concepts and theories, and skill in using laboratory materials'(TGI, 30 April 2019). Under the goal of developing learners' work and career preparation skills, the specific goals were using time effectively, following directions, working productively with others, and committing to accuracy.

Moreover, Wayde also mentioned these specific goals during the SRI to justify his actions during classroom practices. For example, in justifying and explaining his actions for lesson one (i.e., diffraction), Wayde commented:

> the lesson was for learners to understand the topic and to be able to explain how diffraction works and how waves work (SRI, 13 August 2019).

The specific goal for lessons two and three (i.e., the quantitative aspect of chemical change) was:

> They (learners) should be able to use specific laboratory methods to calculate a certain amount of chemicals we may need for experiments, etc. (SRI, 13 August 2019).

Responding to his action in lesson 4, he said:

> With that experiment, I wanted to develop the skills that they needed and also for them to investigate their own understating (SRI, 13 August 2019).

From the above excerpts, Wayde's responses supported his specific goals in TGI and during SRI to develop learners' skills in using laboratory materials and to learn terms and facts. The three specific goals mentioned above support the mid-level goal of developing physical sciences knowledge and skills.

Summary of Wayde's goals. Wayde mentioned that he desired to use active direct for teaching and learning physical sciences from all four case study scenarios in POSTT. Wayde's explanation for his choice of active direct revealed that he knew other orientations (i.e., didactic direct, guided, and open inquiry) discussed in the POSTT. Wayde had two intermediate goals in separate branches to achieve the active direct goal: developing physical sciences knowledge and skills and work and career preparation skills. The specific goals were subsumed under the two intermediate goals. However, in all four lessons, Wayde did not justify his actions related to the second intermediate goal of work and career preparation skills chosen in TGI. He did not explicitly mention the specific goals to develop learners' ability to use time effectively and work effectively with others during SRI. This implies that Wayde struggled to balance his two intermediate goals and classroom practices. Wayde focused more on the goal of developing learners' physical sciences knowledge and skills and less on the goal of preparing learners for work and career skills.

6.4 Teacher beliefs and goals in relation to IBI practices

The above discussion revealed Wayde's teacher-centred beliefs and goals he desired to pursue during classroom practices. Classroom practice findings were necessary to see how his beliefs and goals relate to his actions. In the following section, I first describe Wayde's classroom practice ratings. Wayde's IBI classroom practices were rated using the EQUIP by Marshall et al. (2010). The EQUIP ratings will be followed by data analysis of Wayde's mediating and goal representations in relation to his classroom practices. The EQUIP qualitative analysis was based on four-lesson observations: **Lesson one**: 2D & 3D Wavefront (Diffraction); **Lesson two**: Quantitative aspects of chemical change (Relative molecular mass and formula mass); **Lesson three**: Quantitative aspects of chemical change (calculations); **Lesson four**: Practical investigation: The effects of intermolecular forces on the solubility of different substances (i.e., NaCl, I_2, and $KMnO_4$ in water, ethanol, and chloroform). Then, below in the classroom practices discussion, I provide data analysis responding to research question two on the relationship between beliefs and goals to classroom practices.

Classroom practices

Instructional factor. Wayde had an overall rating of level one (i.e., pre-inquiry) on instructional factors. He scored level one for all indicators under the instructional factor in all four lessons, as indicated in Table 6.2.

Table 6.2

Wayde's EQUIP ratings: Instruction

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
	Instructional Strategies	1	1	1	1
	Order of Instruction	1	1	1	2
Instructional factor:	Teacher Role	1	1	1	1
	Learners' role	1	1	1	1
	Knowledge acquisition	1	2	1	2
OVERALL		**1**	**1**	**1**	**1**

A rating at level one was characterized by teacher-centred dominance in explaining the concepts. The above ratings revealed that the lesson was teacher-centred. Wayde delivered the content through drills and practices by telling or explaining. He predominantly lectured to cover content. For all the lessons observed, Wayde stood at the front of the class and talked most of the time during nearly every class period, including a day when they did a short experiment. Wayde's order of instruction started with him explaining the concepts, and learners did not explore the concepts before the explanation. Wayde stood at the front of the classroom directing learners through homework problem solutions. He was the centre of the lesson and hardly acted as a facilitator. Learners were consistently passive, taking notes, or sometimes one learner reading from the textbook and learning focused solely on mastery of facts, information, and rote processes. Wayde was the centre of the learning activities. In all four lessons, there was much teacher talk and lecture.

Discourse factor. Wayde had an overall score of level one (i.e., pre-inquiry) for a discourse factor. Table 6.3 provides the ratings for the discourse factor and its construct.

Table 6.3

Wayde's EQUIP ratings: Discourse

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
	Questioning level	1	1	1	1
	Complexity of questions	1	1	1	1
Discourse factor	Questioning ecology	1	1	1	1
	Communication pattern	1	1	1	1
	Classroom interaction	1	1	1	2
OVERALL		**1**	**1**	**1**	**1**

The level one rating displayed that Wayde did not engage learners with the questions, challenging them above the remembering level. Wayde's four lessons were categorised at level one because he did not engage learners with the questions, which challenged them above the remembering level. The questions were short answer responses during the lessons focusing only on correct, one-word answers. They were at the knowledge or remembering level, which did not require higher-order thinking skills. When learners gave answers, he accepted, correcting when necessary, but rarely followed up with further probing. His questioning strategy did not lead to discussion. The lesson interaction and communication were just under the teachers' control. Wayde did not encourage learners to ask questions, but their role during the assessment was to answer questions. Wayde's actions led to learners whose thinking was narrowed to what he asked and considered a correct answer. One may infer that learners who had no confidence about their answers' correctness kept quiet, contributing to the lack of class participation. As a result, fewer learners responded to Wayde's questions during the lessons.

Assessment factor. Wayde's summative score was pre-inquiry (i.e., level one) for the assessment factor. Wayde scored at level one for the assessment factor and its constructs, as indicated in Table 6.4.

Table 6.4

Wayde's EQUIP ratings: Assessment

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
Assessment factor	Prior Knowledge	1	1	1	1
	Conceptual Development	1	1	1	1
	Learner Reflection	1	1	1	1
	Assessment Type	1	1	1	1
	Role of Assessing	1	1	1	1
OVERALL		**1**	**1**	**1**	**1**

Level one for the assessment factor indicated that Wayde did not assess learners' prior knowledge. However, learners gained new concepts through memorisation and repetition. Wayde did not connect his lesson introduction to real-world applications during all four lessons. For example, Wayde only asked questions during the lesson introduction to determine whether learners still remembered what was taught in the previous grades on the same topic. The one-word answers did not encourage him to modify his instruction. Wayde's response indicated that he used prior knowledge to recap previous lessons. The formal and informal assessments were for measuring factual knowledge. The role of assessment was to solicit the information from learners and their understanding which required little justification. The questions he asked during all four lessons checked for a surface level of understanding. Wayde did not encourage learners to reflect during the lessons.

Curriculum factor. Wayde has an overall score at level one, i.e., pre-inquiry for the curriculum factor. Table 6.5 provides the rating for the curriculum factor and its constructs.

Table 6.5

Wayde's EQUIP ratings: Curriculum

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
Curriculum factors	Content depth	1	1	1	1
	Learner Centrality	1	1	1	1
	Integration of Content and Inquiry.	1	1	1	1
	Organizing & Recording of Information	1	1	1	1
OVERALL		**1**	**1**	**1**	**1**

Level one rating indicated that Wayde's lessons provided superficial content, did not engage learners, and only focused on content coverage. The lessons provided only superficial coverage of content. During the observed lessons two and three, Wayde asked learners to work on problems in the textbook at the front of the class. The learners go to the front, write the chalkboard solution, and do not explain how they got answers to the whole class. Wayde will only ask if any learner has a different response from the one on the board. If they kept quiet, he would move to the next question. Learners did not engage in activities that encouraged problem-solving skills. There was no linking of content to a bigger picture. Learners were not given the opportunity to explore the concepts in lessons one to three. Even during lesson four, Wayde demonstrated the experiment on the effects of intermolecular forces on the solubility of different substances (i.e., NaCl, I_2, and $KMnO_4$ in water, ethanol, and chloroform). He used the experiment for explaining rather than for learners to explore the concept. All four lessons were at level one, characterised by providing learners with superficial content. During lesson four, learners recorded the practical experiment results in a prescriptive way.

Classroom practices summary: Using EQUIP instrument, Wayde's IBI classroom practices overall rating was at level one, i.e., pre-inquiry level for all the constructs (instruction, discourse, assessment, and curriculum) as indicated in Table 6.6.

Table 6.6

Wayde EQUIP ratings

IBI factor	*Instructional*	*Discourse*	*Assessment*	*Curriculum*	*Overall IBI*
Level	1	1	1	1	1 – Pre-inquiry

Wayde's scores of level one in all factors (i.e., Instructional, Discourse, Assessment, and Curriculum) demonstrated deficiencies in his' IBI practices. There was no improvement in his teaching towards IBI in all four lessons. This was an indication that he was not making any attempt to practice IBI. Pre-inquiry is characterised by traditional classroom practices that are teacher-directed. Wayde was a content disseminator, and learners were the recipients of knowledge. Learning was based on repetition.

Wayde's teaching and learning beliefs and IBI practices. Section 5.3 detailed Wayde's traditional teaching and learning beliefs. In Section 5.4 under classroom practices, Wayde rated level one, pre-inquiry instruction. This section revealed if the teaching and learning beliefs and goals stated by Nelisa were related to her classroom practices.

Wayde held teacher-centred beliefs and focused on the teacher's role in transmitting knowledge. During classroom observations, he was an all-knowing sage. He lectured, reading from the textbook. He would engage learners by asking them to read a definition (e.g., diffraction) or a principle (e.g., Huygens' principle) from the textbook. I observed him explaining the definition that learners had read from the textbook. He was the centre of the lesson. He asked learners to copy the definition and the principle from the textbook into their notes and exercise books.

Wayde believed that learning could be maximised through 'direct, tell and explain' instruction. I observed him providing physical sciences content in a structured manner for his learners' understanding. Firstly, he asked learners to open their textbooks for that day's lesson. He read or asked one learner to read. He read the definitions of the concepts from the textbook and explained them. He asked learners to take notes. Sometimes, he gave examples to the related concept, for example, when he explained a mole concept during lesson two. During lesson three, doing calculations on the quantitative aspect of chemical change, he read problem examples in the textbook and explained the steps in solving problems. Learners did not get a chance to solve the problems for themselves. He drilled one method of solving the problem for learners to memorise.

In determining when learning is occurring in his classroom, Wayde held traditional beliefs. He focused on what learners were doing in class. For example, learners asked questions about the concepts they had discussed or asked him to repeat the explanation. I observed Wayde

explaining concepts or steps involved in solving problems, and learners asked questions. He assumed that learners had learnt the concepts if they did not have questions. He gave the learners homework or a worksheet copied from the different textbooks that learners did not have.
Wayde's response revealed instructive beliefs on determining learners' understanding of physical sciences concepts. He focused on learners' answers to the concept discussed in the classroom to identify whether learners understood. I observed Wayde asking questions and expecting learners to repeat the answers as he explained them. Most of the time, he used informal questioning that required one or short answers during the instruction. If the answer was wrong, he pointed to another learner without further probing why the learner gave that answer.

Wayde believed that learners learn science best when they listen to him explaining and taking notes to read at home. I observed Wayde explain the concepts didactically to learners and wanted them to take notes. He emphasized that learners must listen to him carefully while teaching the concepts, reading from the textbook, and explaining. Then he gave questions to learners, which they solved together. All of Wayde's lessons were content-focused. Even during lesson four, where he demonstrated the effects of intermolecular forces, all the information was on the board. Learners observed the demonstration to confirm what was on the board.

Wayde's goal system and IBI practices. Again, section 6.3 gave an account of Wayde's goal system. Wayde rooted his classroom practices in the specific goals for all his lessons. He adopted the intermediate goal of developing physical sciences knowledge and skills for lessons one, two, three, and four. The specific goals that Wayde explicitly mentioned in the four lessons were for learners to learn terms and facts, concepts and theories, and develop skills in using laboratory materials. I observed the learning of terms, concepts, facts, and theories during the lessons. However, learners did not conduct any experiments to develop process skills. During lessons one, two, and three, he taught learners the concepts of diffraction, Huygens' principle, relative molecular, and formula mass, respectively. During lesson four, he demonstrated the effect of intermolecular forces on the solubility between different substances (i.e., NaCl, I_2, and $KMnO_4$ in water, ethanol, and chloroform). These specific goals reinforce the intermediate goal of developing physical science knowledge and skills.

Furthermore, he adopted an overarching goal of using active direct instruction in the teaching and learning of physical sciences. However, the way the lessons were conducted did not reinforce achieving the overarching goal of active direct. Wayde presented information through the lecture method, drilling learners to know the facts produced by science. The specific goal and intermediate goal reinforce to achieve the didactic direct goal. Wayde's IBI classroom practices overall rating was at level one, i.e., pre-inquiry level. Wayde's goal of active direct did not manifest during classroom practices.

In summary, I observed Wayde's beliefs manifest during classroom practices. These beliefs acted not in isolation but as a system and were identified as traditional. Moreover, his classroom practices were more teacher-centred and focused primarily on learning physical sciences concepts through traditional instruction. Wayde lectured and did not provide opportunities for learners to construct their own knowledge. There was a direct relationship between what Wayde believed and his classroom practices. Again, Wayde adopted an overarching goal of using active direct in the teaching and learning of physical sciences. However, Wayde's professed active direct goals did not align with his pre-inquiry classroom practices. He adopted an active direct goal, but his classroom practices consisted of lecturing, content transmission, and drilling learners to grasp the content. There was no direct relationship between Wayde's classroom practices and his goal since his practices manifested a didactic direct goal.

6.5 The influences on teacher beliefs, goals, and IBI practices

This section provides a synthesised analysis that combines the findings from Wayde's teaching and learning beliefs and goals that guided his classroom practices.

Beliefs and goals. The above findings revealed that Wayde's traditional teaching and learning beliefs did not align with the overarching active direct goal. Wayde expressed beliefs aligned with his classroom practices yet nonaligned to his overarching instructional goal. As indicated above under section 6.3, Wayde's classroom practices were overall rated as pre-inquiry. Wayde's traditional teaching and learning beliefs promoted knowledge transmission, passive learners, and the teacher who regards himself as an expert. Wayde's traditional beliefs influence his pre-inquiry classroom practices. However, Wayde's overarching goal to use active direct did not manifest during classroom practices. Even though Wayde adopted the overarching goal of providing learners with active, hands-on experiences, he could not accomplish that during classroom practices. Instead, his actions observed were 'steering learners' in a specific direction and 'giving them ground to work on.' The overarching goal observed from his classroom practices manifested a didactic direct goal focused on transmitting facts and knowledge. The specific goals aligned with the intermediate goals but did not achieve the overarching goal of active direct instead achieved didactic direct.

Social and physical context. Wayde indicated some contextual factors that assisted him in accomplishing his goal. During SRI, Wayde specified CAPS and textbooks as the curriculum resources which determined what to teach. This is how Wayde explained the use of curriculum resources:

> So when I planned the lesson, I first used the CAPS documents, so I looked at whether my lesson kept in line with or with the goals of the particular topics they wanted in that lesson.
>
> Most often, I use textbooks. I also use the worksheets on notes and use the chalkboard now and then (SRI, 13 August 2019).

He mostly used the CAPS document as a guide to teaching physical sciences and relied mainly on the textbooks. Even though Wayde was satisfied with the CAPS document, he was also concerned that the physical sciences curriculum was restrictive. Wayde's concern was:

> Maybe concerning curriculum, sometimes, I feel like it is too closed at the school level. There is too much that learners can be learning in specific topics or individual sections. The curriculum can keep you on particular topics, and you have these learners that are doing extra research, coming with questions that is why I have to be prepared all the time (SRI, 13 August 2019).

Wayde felt that following the prescribed textbook, examination guidelines, and annual teaching plan makes it challenging to go the extra mile. Another concern about the curriculum was that it contained too many topics to be taught within a specific time. He commented:

> Also, due to time constraints, there is a difference in learners' level of understanding. Active direct would allow learners to gain the same pre-conceived knowledge and draw the same conclusions during the hands-on activities (SRI, 13 August 2019).

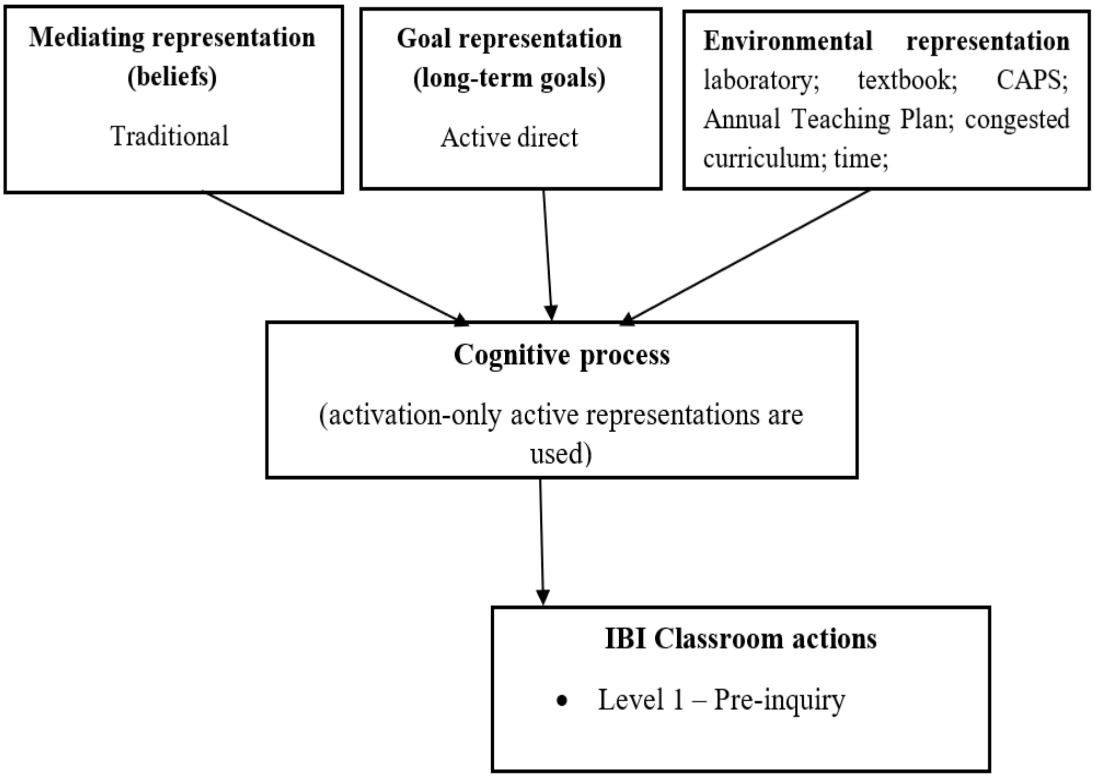
He was concerned about time constraints, which he assumes contributes to learners' lack of understanding of the concepts and limited time for practical work.

6.6 Summary of findings

This chapter detailed Wayde's teaching and learning beliefs, the goals he pursued, and the IBI level during classroom practices. Figure 6.2 summarizes Wayde's findings, as explained in this chapter.

Figure 6.2

Wayde's beliefs, goals, and environmental representations summary



Wayde held traditional teaching and learning beliefs. He professed that he adopted an overarching goal of active direct. However, the goal that manifested during classroom practices was didactic direct. The environmental factors that supported his classroom practices were the annual teaching plan and textbook. His school had a laboratory, but he was not using it. The interpretation of these findings is discussed in chapter nine. The following chapter seven presents the third case.

CHAPTER SEVEN

DATA PRESENTATION: CASE THREE - AMALIA

7.1 Introduction

This chapter presents Amalia's cases. As stated in chapter five, this chapter starts by describing Amalia's background information and environmental context. The environmental context description follows Amalia's beliefs and goals about IBI in the discussion of classroom practices. This discussion follows a relationship between knowledge, beliefs, and goals to classroom practices. Finally, the chapter summarizes Amalia's beliefs, goals, environmental context, and IBI practices.

7.2 Background and context

Personal background. During data gathering, Amalia was a 26 year's old Indian female teacher with three years of teaching experience. She held a Bachelor of Education (BEd) degree specialising in physical sciences and geography education. Amalia studied three physical sciences education method modules during her BEd programme. In addition, she was studying towards her Bachelor of honours, BEd(Hons) degree in leadership and management. Amalia taught physical sciences in grade 10 and mathematics in grades eight and nine. She had attended several workshops organised by DBE and facilitated by SES. Amalia enjoyed teaching physical sciences. She mentioned that she gained more knowledge of some content that she clearly did not understand from her undergraduate degree when preparing for her lessons. She explained:

> as a teacher, you know that this is the topic that I need to teach, and as you teach it, you realise that there is something that you have missed, so you are building on your knowledge at the same time you are learning something new all the time. That is what I like about physical sciences (SRI, 12 August 2019).

Amalia had a healthy relationship with learners and the science teachers within the department. As a novice physical science teacher, she was guided and mentored by the HOD and senior teacher within the department.

School setting. During the data gathering year, Amalia was teaching in a public government semi-urban school, ex-model C, situated in a primarily Indian community. The school has a very diverse population of Black African and Indian learners. There were 713 learners and 25 teachers. The learner population is 60% Indians and 35% Black African, and 5% Coloureds. Most of the learners come from the middle-class Indian community. The school was well resourced and well maintained. Two physical sciences laboratories were used by both senior and FET phase learners. There was also a computer laboratory. The school was well maintained and clean. The science department had five physical sciences teachers and one departmental head. The school was classified as quintile 4, meaning learners must pay school fees and have no feeding schemes. The school day consisted of six periods of 60 minutes each, three periods before and after one long break.

Classroom setting. Amalia had 25 learners in her physical sciences class. The class size was a manageable number. Learners used laboratories as the venue for teaching and learning physical sciences, natural sciences, and life sciences. According to the timetable, they would move to the laboratory venue when it was time for these subjects. She was using the physical sciences laboratory to teach. In her school, learners progress to different classrooms when it is a period change.

7.3 Teacher beliefs and goals about IBI

Amalia's teaching and learning beliefs. Data analysis from TBI revealed that Amalia's beliefs are categorised as **instructive,** according to Luft and Roehrig's (2007) protocol. The instructive beliefs category indicated that Amalia held teacher-centred beliefs about teaching and learning. Below, I provide further analysis of TBI that supports responsive beliefs with sample responses for each question. The section below is organised according to the questions taken from TBI.

Amalia's beliefs about the teacher's role. Amalia held instructive beliefs about her role as the IBI teacher. She perceived herself as a 'facilitator of knowledge,' whereas her explanation was more instructive. Amalia responded that her teacher's role was:

> I am a facilitator of knowledge. I explained the concept from the bare minimum (basics) to a difficult section or question. So, I explain, do various exercises, and examples from previous question papers and then mark them (TBI, 22 April 2019).

During SRI, Amalia explained her role as:

> It is to make learners aware of the science around them and equip them with skills, knowledge, and values that will help them one day go to the field and create careers for themselves (SRI, 12 August 2019).

In the above quotations, Amalia's response on facilitation reflected that she perceived her role as a teacher that needs to provide learners with learning opportunities. Thus, even though her response during SRI was on developing conceptual understanding, she focused on what she does for learners, including different activities. Amalia's beliefs on teachers' roles were categorised as teacher-centred because she focused on what she was doing, not on learners' needs and collaborative learning.

Amalia's beliefs about maximising learning. The overall coding classified Amalia's beliefs about teaching as instructive. Her comments focused on guiding learners in developing physical sciences content and skills. When asked how she maximised learning in her classroom, she responded:

> I maximise learning by using various resources such as ppt, PhET, textbooks, excursion (Eskom power plant) past year papers. I also allowed senior physical science teachers to teach a specific topic that I knew I was not confident in. By so doing this, I learn as well. The most fantastic resource is the past year's papers learners learn a lot from here. I constantly ask questions and link the topic to something we do daily, e.g., electricity (TBI, 22 April 2019).

Amalia's response to the above excerpt emphasised the focus on her actions and what she was doing for learners using different resources. For example, she gave learners activities from previous question papers and controlled them to monitor if they could solve those questions. She also emphasised using other activities and resources, like consulting with the senior teachers and excursions. Amalia held teacher-centred beliefs about maximising learning in her classroom because she focused on direct instruction and the transfer of content knowledge. For classroom interaction, she focused on teaching rather than learning.

Amalia's beliefs about how learning is occurring. Amalia's beliefs about physical sciences learning through inquiry were classified as transitional. In her response, she emphasised learners' characteristics: working together, sharing ideas, and taking ownership of their learning through hands-on activities. For example, this was her response to how she knew that learning was occurring in her class:

> While they are doing practical work, they are working in groups to develop skills, and when learning, they are developing skills. Learners ask questions, pose a problem that could occur, and ask me about it. Learners try to bring prior knowledge and link it to the concept (TBI, 22 April 2019).

Amalia's response was neither learner nor teacher-centred. However, she focused on engaging learners as active participants in teaching and learning through practical work. Her response reflected her learners' actions and observations during learning. For example, learners were involved in hands-on activities and asked questions.

Amalia's beliefs about learners' understanding of concepts. The coding classified Amalia as having instructive beliefs on knowing if learners understand the concepts of the physical sciences. She provided an explanation and stated:

> I ask questions, so if they answer correctly, I know they understand. I also do follow-up exercises, so by answering this, I can see if learners understand (TBI, 22 April 2019).

The above excerpt revealed that Amalia focused on asking questions after teaching the topic and monitoring learners' responses to the content presented during teaching and learning. Depending on whether their responses were wrong or correct, she determined if learners understood or not. These beliefs are classified as teacher-centred since the focus is on product-orientated assessment.

Amalia's beliefs about how learners learn science best. Amalia's beliefs on learning physical sciences best through IBI were also categorised as transitional. She explained:

> Learners ask questions. Learners also try to construct meanings with my aid of me. Try to figure out why this phenomenon is like this (TBI, 22 April 2019).

Amalia's belief was neither teacher nor learner-centred because her response indicated procedural classroom activities. Even though Amalia was rated as transitional, I classified her beliefs as teacher-centred because she wanted to be part of the learning process rather than allowing learners to construct their knowledge.

Summary of Amalia's teaching and learning beliefs. Table 7.1 profiles the overview of Amalia's beliefs about physical sciences teaching and learning, which were overall coded as instructive. The emphasis on instructional beliefs is on teacher-directed learning. Even though instructive is not a traditional belief, the focus is still on the teacher as the main source of knowledge. Some attention is given to learners' participation in the lessons.

Table 7.1

Summary of Amalia's teaching and learning beliefs

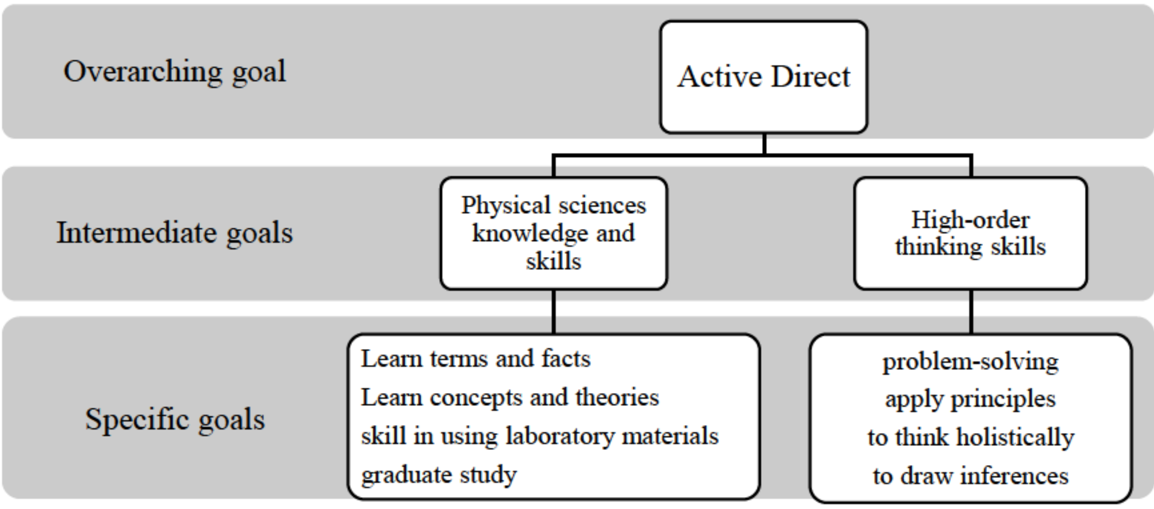
	QUESTION	RESULTS	REASON FOR CHOICE
TEACHING BELIEFS	How do you describe your role as a teacher?	Instructive	- I explain, do various exercises, and examples from previous question papers - to make learners aware of the science around them
	How do you maximise learning for your learners?	Instructive	- Using various resources such as ppt, PhET, textbooks, excursion (Eskom power plant) past year papers. - I constantly ask questions and link the topic to something we do daily
LEARNING BELIEFS	How do you know when learning is occurring in your class?	Transitional	- Learners construct meanings - learners ask questions - learners bring on prior knowledge
	How do you know your learners understand?	Instructive	- If they answer questions correctly - By answering follow-up exercises
	How do your learners learn science best?	Transitional	- learners construct meanings - learners pose questions

From the above analysis, I describe Amalia as having teacher-centred beliefs consistent with a traditional approach to teaching and learning. Even though the instructive beliefs category represents teacher-centred beliefs, it provides an opportunity for learners to be hands-on. Firstly, Amalia regarded her teaching role as an expert in physical sciences. Her teaching beliefs were about using different teaching strategies. Secondly, she believed that learning occurs when direct instruction and knowledge production through assessment with some consideration of prior knowledge. Finally, even though she believed in learner participation, she regarded learners as consumers of knowledge.

Amalia's goal system. Amalia's goal system was developed and hierarchically arranged from her responses in POSTT (25 April 2019), TGI (30 April 2019), and SRI (12 August 2019). Figure 7.1 indicates a streamlined hierarchical arrangement of Amalia's goals. Amalia's goals existed in a hierarchy with different levels of abstraction. The specific goals at the lowest level and the overarching (i.e., abstract) goal at the highest level. In between, there were two intermediate goals. The first goal set focused on developing physical sciences knowledge and skills, and the second goal set focused on developing high-order thinking skills. Below, I detailed the analysis of each goal with sample responses.

Figure 7.1

Amalia's goal system



Amalia's overarching goal. Amalia's overarching (abstract) goal was to use active direct for physical sciences instruction. Explaining why she chose active direct to didactic direct, guided, and open inquiry, she said:

> Active direct assist me in giving them a push so that they can go and study that phenomenon. Sometimes, learners are lazy and do not want to learn independently (SRI, 12 August 2019).

Elaborating on her choice of active direct, she explained:

> I don't use guided and open inquiry because it places too much freedom on the learners, and my learners would not do that. It could just be ambiguous and lead them in the wrong direction (SRI, 12 August 2019).

Amalia's active direct choice revealed some responsibility in guiding her learners in their development. She did not trust her learners to work independently. On the other hand, Amalia did not choose didactic direct instruction since she believed it was 'feeding learners information' (SRI, 12 August 2019).

Amalia's intermediate goals. One of Amalia's intermediate (mid-level) goals was to equip learners with physical sciences knowledge and skills (TGI, 30 April 2019). In addition, she wanted to create a background understanding of the subject so that after grade 12, these learners will choose a science career. Emphasising the same goal during the SRI, she mentioned that:

> It is to make learners aware of the science around them and equip them with skills, knowledge, and values to help them one day go to the field and create careers for themselves (SRI, 12 August 2019).

Amalia desired to design opportunities for learners to develop the knowledge and skills to engage and use them for their future endeavours. It was equally important to Amalia for learners to understand the physical sciences' concepts, not memorize them. Moreover, learners needed to enjoy the subject. She explained:

> I expect them to learn efficiently and not just memorised things, and they must be able to understand it and use that knowledge (SRI, 12 August 2019).

Amalia desired her learners to learn the content they were required to learn for conceptual understanding beyond memorising.

Amalia's second intermediate goal that she pursued was to help learners develop high-order thinking skills (TGI, 30 April 2019). She believed that physical sciences teaching and learning should develop problem-solving and critical thinking in learners. Explaining what she meant about critical thinking, she responded:

> I expect them [learners] to ask questions about why this is happening. For example, a learner may ask, 'but mam, this is happening this way …but in the textbook, they say it happens this way…so why is it not the same…'. So this discussion can occur when we are doing practical work or during the regular lesson in class when discussing the concepts (SRI, 12 August 2019).

For Amalia, teaching physical sciences must exercise learners' minds to enable them to ask 'why' and even go further to ask 'what if' for knowledge construction. Amalia's critical thinking involved the application process. For achieving the intermediate goal mentioned above, Amalia's specific goals were developing learners' problem-solving, applying principles, thinking holistically, and drawing inferences skills.

Amalia's specific goals. Amalia mentioned specific goals as essential in teaching and learning physical sciences under these two mid-level goals. Under the goal to develop physical sciences' knowledge and skills, the specific goals were to 'learn terms and facts, learn concepts and theories, skills in using laboratory materials, and graduate study' (TGI, 30 April 2019).

During the SRI, Amalia also mentioned these specific goals that drove her classroom actions. She responded:

> to make sure that learners understand the importance of science, they develop the necessary science skills and enjoy science as a whole (SRI, 12 August 2019).

When asked about her action and behaviour during lesson one, where they were revising the previous question papers, she justified her actions and said:

> I wanted learners to become familiar with the way questions are asked during the examination. We usually just teach the content, but when they see how questions are asked, how marks are allocated, and how they are supposed to respond, they will become confident during the examination (SRI, 12 August 2019).

Amalia taught the physical sciences content and then boosted learner confidence by revising previous question papers.

During lessons two and four, learners conducted the experiments using PhET simulation on series and parallel connection and acceleration. Amalia justified her desire to teach using PhET simulations and said:

> PhET simulation makes explanations easier for learners… it is much easier for learners to understand the concepts of flowing charges in a circuit. So, basically, learners can see more clearly, and our practical work is constantly being upgraded. PhET simulations assist learners in learning scientific knowledge and developing skills because they can take data from it, make conclusions, yah, etc. Learners were able to take correct measurements readings of the ammeter and voltmeter across the series and parallel circuit and make the proper conclusion based on that current and voltage. Based on PhET simulations on the ticker time, they were able to analyse the tape based on the motion of the trolley and spacing of the dots (SRI, 12 August 2019).

Amalia used simulations for explaining instead of allowing learners to explore the concepts. Moreover, learners developed basic process skills like observing, taking readings, and drawing conclusions.

Summary of Amalia's goals. Amalia had an overarching goal of using active direct. In Amalia's case, the goals within her goal system were reinforcing. The progress towards maintaining the overarching goal resulted in the satisfaction of the intermediate and specific goals. For example, Amalia's specific goal for learners to learn terms and facts supported the intermediate goal of developing knowledge and skill, which supported the overarching goal for active direct. One observation is that during SRI, Amalia did not mention the specific goals that she pursued for learners to develop high-order thinking skills during SRI. She focused on one intermediate goal of developing learners' knowledge and skills. However, some of these specific goals manifested during the lesson. For example, after the simulation, learners applied the principle to solve problems based on acceleration in lesson four. They predicted the results of the experiment.

7.4 Teacher beliefs and goals in relation to IBI practices

The above discussion revealed Amalia's teacher-centred beliefs and the goals she pursued during classroom practices. Classroom practice findings were necessary to see how her beliefs and goals relate to her actions. In the following section, I firstly describe data analysis for Amalia's classroom practice ratings. Amalia's IBI classroom practices were rated using the EQUIP by Marshall et al. (2010). The EQUIP ratings will be followed by data analysis of Amalia's mediating and goal representations in relation to her classroom practices. The EQUIP qualitative analysis was based on four-lesson observations: **Lesson one**: Electric circuits; **Lesson two**: Practical Task: Electric circuits; **Lesson three**: Electrolyses; **Lesson four**: Practical investigation: Acceleration. Then, after the classroom practice discussion, I provide data analysis responding to research question two on the relationship between beliefs and goals to classroom practices.

Classroom practices

Instructional factor. Amalia scored an overall rating at level two (i.e., developing inquiry) for the instructional factor. Table 7.2 tabulates the rating for each construct under the instructional factor.

Table 7.2

Amalia's EQUIP ratings: Instruction

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
	Instructional Strategies	2	2	2	2
	Order of Instruction	2	2	2	2
Instructional factor:	Teacher Role	2	2	2	2

	Learners' role	2	3	2	3
	Knowledge acquisition	2	2	2	2
OVERALL		**2**	**2**	**2**	**2**

A rating at level two indicated that Amalia's classroom practices were teacher-centred as she lectured in all four lessons observed. All four lessons were teacher-centred, even though somehow learners were engaged throughout the lessons. Amalia acted as a facilitator at a minimal level as she lectured most of the time. Even with the practical work done during lessons two and four, Amalia used it to explain the concepts instead of learners exploring concepts. During lesson two, learners were doing a PhET simulation on the series and parallel connection of cells. It was the same as lesson four, where learners were engaged in a PhET simulation for acceleration after discussing the concept. Learning focused on mastery of facts and a little focus on understanding the content. Amalia focused on the learners' skills to answer the questions and also to be able to compare the mark allocation to the steps required in the calculation or stating the definition. Amalia primarily initiated the interaction between teacher and learner. She read the questions from a question paper for knowledge acquisition and allowed learners to attempt the problem in pairs before the whole class discussed the problem. Amalia used a few cooperative learning elements by enabling learners to work in teams to solve the problem before involving the entire class. Learners were minimally active as they depended on the teacher to initiate the conversation.

Discourse factor. Again, Amalia scored at developing inquiry (i.e., level 2) for the discourse factor. Table 7.3 provides the rating for the discourse factor.

Table 7.3

Amalia's EQUIP ratings: Discourse

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
	Questioning level	2	2	2	2
	Complexity of questions	2	2	2	2
Discourse factor	Questioning ecology	2	2	2	2
	Communication pattern	2	2	2	2
	Classroom interaction	2	2	2	2
OVERALL		**2**	**2**	**2**	**2**

Level two indicated that Amalia's questioning and discussions, though present, were not at the required level, and learning activities lacked opportunities for critical thinking. Amalia used the previous question papers during the lessons for teaching and revision. The questions from previous question papers and the worksheet challenged learners to remember and understand, and there were few questions on the application or analysis level. As indicated in the excerpt from the assessment below, Amalia's questions vary and focus on one-word, open responses (e.g., the definition of emf, stating laws) and calculations. Amalia accepted learners' answers and corrected them with little input from other learners. Moreover, the excerpt indicated that Amalia successfully engaged learners in the discussion through a question and answer strategy. During the lessons, the communication was directed by Amalia even though learners were also actively participating and answering questions.

Assessment factor. Amalia was also rated at level two, developing inquiry for assessment factor. Table 7.4 provides the EQUIP rating for the assessment factor.

Table 7.4

Amalia's EQUIP ratings: Assessment

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
	Prior Knowledge	2	2	2	2
	Conceptual Development	2	2	2	2
Assessment factor	Learner Reflection	1	1	1	1
	Assessment Type	2	2	2	2
	Role of Assessing	2	2	2	2
OVERALL		**2**	**2**	**2**	**2**

Amalia's level two assessment factor means that her informal assessments generally measured learners' factual knowledge. Amalia did not assess learners' prior knowledge but used questioning to recap what was done in the previous lessons using the question and answer method but did not modify the lesson instruction based on this knowledge. During the informal assessment, she asked questions that encouraged answer-focused learning activities that lacked critical thinking. She encouraged a question-answer format that involved factual knowledge and wanted her learners to answer and explain according to the examination guidelines. She did not encourage learners to reflect on their learning at any stage of the lessons. At the end of the lessons, she also checked for learners' understanding through questions and answers before giving them homework.

Curriculum factor. Amalia's summative score was at level 2, developing inquiry. Table 7.5 provides a curriculum factor rating for all four lessons.

Table 7.5

Amalia's EQUIP ratings: Curriculum

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
Curriculum factors	Content depth	2	2	2	2
	Learner Centrality	2	2	2	2
	Integration of Content and Inquiry.	2	2	2	2
	Organizing & Recording of Information	2	2	2	2
OVERALL		**2**	**2**	**2**	**2**

The above level two rating indicated inadequate depth to the content covered. Activities planned for learners were not adequately focused on inquiry. The content depth of the lessons was at an observational level. Lessons 2 and 4 both provided hands-on activities with anticipated results. During lesson 2, learners have to compare the current at all points in a series circuit and compare each resistor's potential difference in a parallel circuit. The two investigations linked well with the content, but Amalia did not connect to the bigger picture in electricity and mechanics, respectively. For both lessons, learners had minor input on recording and organizing their observed information since the teacher gave them an open worksheet to complete.

Classroom practices summary: Using EQUIP instrument, Amalia's IBI classroom practices overall rating was at level two, i.e., developing inquiry level for all the constructs (instruction, discourse, assessment, and curriculum) as indicated in Table 7.6.

Table 7.6

Amalia EQUIP ratings

IBI factor	Instructional	Discourse	Assessment	Curriculum	Overall IBI
Level	2	2	2	2	2-developing

Developing inquiry, i.e., level two is characterised by teacher-directed traditional classroom practices with some learner participation. Even though the lessons were teacher-focused, Amalia engaged learners and used assessment to capture learners' knowledge and understanding. She did not design and conduct investigations but used PhET simulation instead. However, there was no indication of movement to proficiency level. Amalia rated level two in all the IBI factors with no indication of an increased developing inquiry level.

Amalia's teaching and learning beliefs and IBI practices. The analysis under section 7.3 above described Amalia as having teacher-centred (i.e., instructive) teaching and learning beliefs. In Section 7.4, Amalia's classroom practices were rated at level two, developing inquiry. This section revealed how Amalia's teaching and learning beliefs and goals relate to her classroom practices.

Amalia believed that the role of the teacher was to be a guide and was skeptical about letting learners work independently, as she wanted to guide them to the correct path. During classroom observations, I observed her role as a guide of learning. She lectured most of the lessons. For example, learners were minimally active when working on simulations. When revising the previous question, she allowed learners to work in pairs and discuss the question as a whole group.

Amalia believed that learning could be maximised by providing experiences for learners through different activities like excursions and simulations, where they will be hands and minds-on. I observed Amalia engaging learners in simulation to explain the sciences concepts. During lesson one, Amalia asked questions from the previous question paper, allowed learners to discuss the answer, and shared with the whole group to monitor if they could solve the problem.

Amalia's beliefs about determining when learning is occurring focused on her learners' behaviour. She believed that learners work together, share ideas, and take ownership of their learning through hands-on activities. During classroom practices, I observed learning through hands-on activities. However, the sharing of ideas and working together were at a minimal level.

In determining how learners understand physical sciences concepts, Amalia believed that learners answer questions and follow up correctly after teaching the topic. I observed Amalia use informal questioning and ask questions of learners. If learners' responses were correct, she would assume they understood. If learners' responses were incorrect, she would explain, drawing them to the correct answer.

Amalia believed that learners learn science best when they ask questions and construct meanings but with her assistance. During classroom observation, Amalia did not give learners a chance to construct meanings of the concepts studied. However, learners engaged with experiments and solved problems.

Amalia's goal system and IBI practices. Again, section 7.3 gave an account of Amalia's goal system. Amalia attributed the specific goals to developing physical sciences knowledge and skills in lessons one to four. I observed during the lessons Amalia assisted learners in learning terms, concepts, facts, and theories. During lessons one and two, learners discussed series and parallel connections of resistors. They further differentiated between current flow in series and parallel circuits. They observed the series and parallel connections using PhET simulation during lesson two. These specific goals reinforce the intermediate goal of developing physical science knowledge and skills.

Moreover, Amalia adopted an overarching goal of using active direct instruction in the teaching and learning of physical sciences. Amalia's IBI classroom practices overall rating was at level two, i.e., developing inquiry level. Therefore, there was a direct relationship between Amalia's classroom practices and her overarching goal.

In summary, Amalia's teaching and learning beliefs were categorised as teacher-centred, including active learner participation. Amalia used computer software (PhET simulations) to involve learners in hands-on activities during classroom practices. Amalia's teaching and learning beliefs were categorised as instructive, and her classroom practices were rated at level two, developing inquiry. There was a direct relationship between Amalia's classroom practices and her teaching and learning beliefs. Furthermore, Amalia's specific goals were reflected in her actions during classroom practices and reinforced the achievement of her overarching goal. The goal of using active direct aligned with Amalia's classroom practices rated as developing inquiry.

7.5 The influences on teacher beliefs, goals, and IBI practices

Beliefs and goals. The above findings revealed that Amalia had teacher-centred beliefs aligned with her active direct overarching goal. Her beliefs and goals were reflected in her behaviour during classroom practices. Amalia's responses indicate that she was committed to her beliefs and active direct goal. She said that 'physical sciences can be enjoyable and be more understandable by allowing learners to be hands-on. Didactic direct is like feeding learners, and active direct works well in my specific context' (SRI, 12 August 2019).

Social and physical context. Amalia indicated a commitment to her instructive beliefs and active direct goals as she explained:

> I think active direct is the best to use in my context, and it saves time and allows me to go over every section and have time for revision and go over past years' papers when the exams are near (SRI, 12 August 2019).

Amalia's comment revealed that the school context and time constraints impacted her classroom practices. She mentioned the positive effect on the social and physical context supporting her teaching. During SRI, she recommended the mentorship that she received from her physical sciences senior teacher. Her school had a physical sciences laboratory with sufficient equipment and materials for teaching and learning. Explaining about the curriculum resources, she said:

> The most helpful document I used is the examination guidelines given by the Department of Basic Education (DBE), a white booklet with all the definitions and the section that we must cover in grades 10,11 and 12. There are different books for each grade. That gives us precise definitions and precise explanations. At the back of that book, there are previous examination question papers that allow us to test learners' knowledge at the same time. I regard it as an updated version of the CAPS documents. It does not have activities but gives guidelines. For example, it will define vertical projectile motion and other concepts (SRI, 12 August 2019).

Moreover, Amalia seemed to rely more on SES guidance than the CAPS document. Commenting on her reliance, she said:

> I followed the guidance from my subject advisor, not necessarily the CAPS documents because my SES sought of alters the CAPS in a way. Sought to bring other topics forward and take other topics out or tell us to do additional experiments

and stuff (SRI, 12 August 2019).

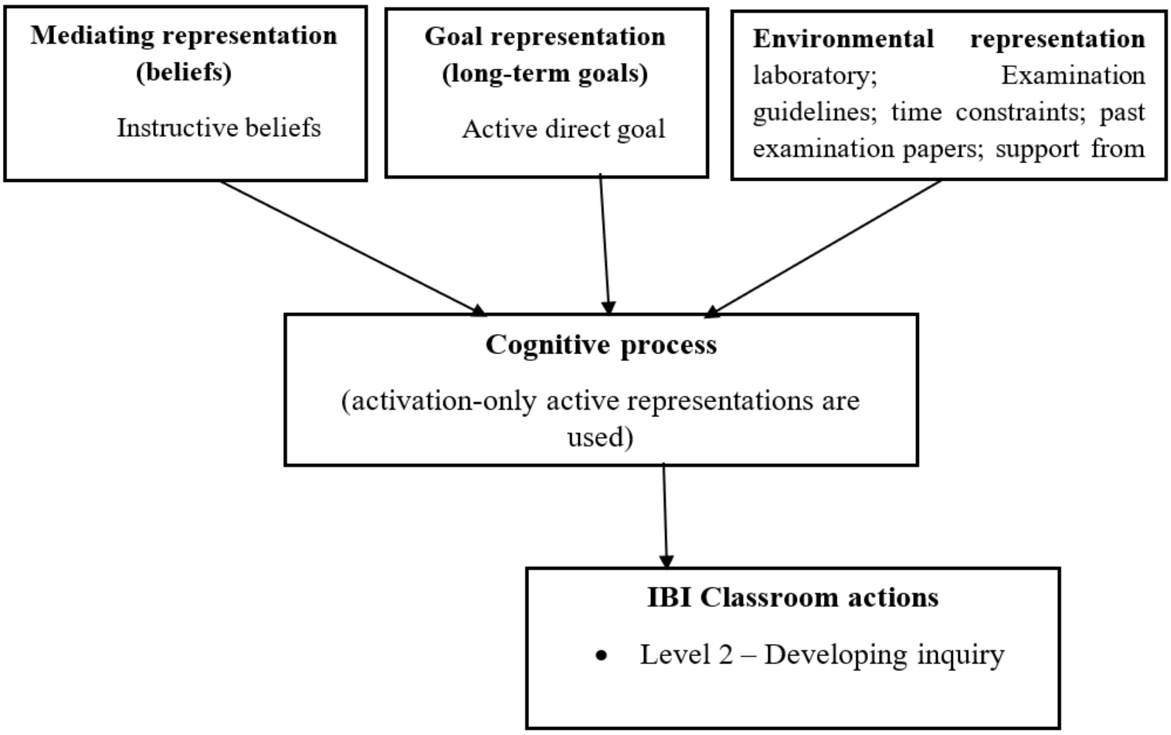
Amalia followed what was discussed in the workshops she attended. She felt obliged to follow the SES directive because learners were writing common tests from the district, and that continuous assessment mark contributed to the final examination mark.

7.6 Summary of findings

This chapter detailed Amalia's teaching and learning beliefs, the goals she pursued, and the IBI level during classroom practices. Figure 7.2 summarizes Amalia's findings, as explained in this chapter.

Figure 7.2

Amalia's beliefs, goals, and environmental representations summary



Amalia held responsive teaching and learning beliefs. She adopted an overarching goal of active direct. The environmental factor that supported her classroom practices was the support from her district SES for guidance on what to teach. She also used the DBE book with previous question papers. The interpretation of these findings is discussed in chapter nine. The following chapter eight presents the fourth case.

CHAPTER EIGHT

DATA PRESENTATION: CASE FOUR - GATSHA

8.1 Introduction

This chapter presents the last case of the four cases. As stated in chapter five, this chapter starts by describing Gatsha's background information and environmental context. The environmental context description is followed by Gatsha's knowledge, beliefs, and goals about IBI to classroom practices discussion. This discussion is followed by a relationship between beliefs and goals to classroom practices. In the end, the chapter summarizes Gatsha's beliefs, goals, environmental context, and IBI practices.

8.2 Background and context

Personal background: During data gathering, Gatsha was a 27-years Black African male teacher with three years of teaching experience. He held a Bachelor of Education (BEd) degree specialising in physical sciences and mathematics education. He was studying towards his Bachelor of honours (BEd Hons) degree in Mathematics and Science Education for professional development. He taught physical sciences in grades 10, 11, and 12 and mathematics in grades 8 and 9. As a grade 10-12 physical sciences teacher, he attended several workshops organised by the DBE and facilitated by the SES. He was passionate about teaching physical sciences. According to Gatsha:

> Physical sciences teaching is for critical thinkers. It opens the minds of the learners. It brings learners close to the technology they learn to operate those things. For example, in grade 12, learners learn about generators…

Gatsha had a healthy relationship with his learners as well as the science teachers within the department.

School setting: Gatsha was teaching in a public secondary school situated in a township. The school was from grades 8 to 12, with an enrolment of 987 Black African learners. Before being upgraded to secondary school, the school was a primary school six years before data gathering. Learners enrolled in the school came from low-income communities. The school was classified as quintile two and a no fee-school since it was situated within a poor neighbourhood. Because of its quintile, the learners receive lunch at school. There were five teachers in the department of sciences, of which one was the departmental head. There were no laboratories, apparatus, chemicals, or even textbooks. Gatsha mentioned that the boxes with a few pieces of equipment and material for grade 12, which they had received the previous year, were kept in the departmental head office due to the lack of space.

Classroom setting: Gatsha had an overcrowded class of 50 grade 10 physical sciences learners. Gatsha's classroom was arranged in a traditional setting, with four rows of desks facing the chalkboard with one table in the front. The grade 10 science learners use this classroom for all other subjects. The teachers in this school are the ones that move to classes during their teaching time.

8.3 Teacher beliefs and goals about IBI

Gatsha's teaching and learning beliefs. Data analysis from TBI revealed that Gatsha's belief system was categorised as **instructive,** according to Luft and Roehrig's (2007) protocol. The instructive category indicated that Gatsha held teacher-centred beliefs about teaching and learning. Below, I provide further analysis of TBI that supports instructive beliefs with sample responses for each question.

Gatsha's beliefs about the teacher's role. Gatsha's beliefs about his role as a physical sciences teacher were instructive. Gatsha gave a more detailed response as he defined his role and stated:

> As a science teacher, I help learners understand a body of information and scientific investigations. So that learners can be educated and easily understand the concept of physical science. I set the goals or objectives of the lesson. Developing the goals helps me identify what needs to be covered during a lesson. Furthermore, I decide the activities that learners will do in class. Also, use a variety of teaching strategies to accommodate different learners. Assess learners' progress using formal or informal tasks. Using a combination of teaching strategies helps me accommodate slow and fast learners in my class. Assessing learners help in finding out what learners know (TBI, 22 April 2019).

Gatsha echoed the same response during the SRI when asked about his role in physical sciences teaching and learning. He elaborated and said:

> As a physical science teacher, my role is to make sure that I create a conducive classroom for learners. I create a space for them to do experiments so that they can do experiments to figure out the science concepts. Another one is to ensure that learners understand the concepts and have the knowledge required in physical sciences (SRI, 18 August 2019).

Gatsha's responses in the above quotations focused on the activities and experiences that he provides to learners. He emphasised the creation of a conducive learning environment. Again, he described his role from the point of view of what he as a teacher is doing for learners rather than how it is helping learners to learn physical sciences. He regarded himself as an expert and allowed learners an opportunity to find information on their own. Gatsha was categorised as holding teacher-centred beliefs because he revealed learners as consumers of knowledge as he made sure that all activities were provided.

Gatsha's beliefs about maximising learning. Gatsha was coded traditional for his response on how he maximised the learning of physical sciences. According to Gatsha, the maximising of learning was not about what learners engage in during teaching and learning but was about him ensuring that he is well prepared to engage learners. He explained:

> Through better planning and preparation, the lesson. By giving learners explicit instruction and what is their explanation in the lesson. Ensure that I monitor the class in terms of distractions so that learners can focus. Through using different strategies and approaches when teaching. By choosing appropriate activities suitable for learners (TBI, 22 April 2019).

Gatsha believed that learning could be maximised by providing physical content in a structured manner and class management. He assumed that using different teaching approaches would better help learners understand physical sciences. His beliefs were characterised as teacher-centred as his choice of approach emphasised direct instruction and knowledge production.

Gatsha's beliefs about how learning is occurring. Gatsha's response to how the learning occurred in his physical sciences classroom was coded as instructive. He emphasised the monitoring of learners' responses by saying:

> Through responses that learners give when questions are asked. Through answers when learners are given class activities. Also, when they are given informal or formal tasks. Lastly when they discuss their findings in group work and make presentations on their findings (TBI, 22 April 2019).

Gatsha gave assessment tasks to learners, and if students were able to solve the problems in the tasks, he assumed that they had learned the content. Gatsha's beliefs were teacher-centred as it revealed the measures that he focused on learners' performance and actions during classroom interactions. Even though his beliefs were teacher-centred, learner participation was an element when working in groups.

Gatsha's beliefs about learners' understanding of concepts. Gatsha's learning belief was coded instructive as he indicated that he measures learners' understanding of physical sciences concepts by repeating the work done in the classroom. He explained:

> From their explanations and discussions when they are asked questions. I gave them formal and informal tasks. Also, when presenting their findings and discussing them in groups. By giving them a classroom where they will write their understanding when answering questions (TBI, 22 April 2019).

Gatsha explained that during the instruction, he used informal questioning and asked questions of learners. So, depending on whether their responses were correct or incorrect, he determined if learners understood or not. Moreover, if learners asked questions during group discussions, he assumed they understood from those responses. Gatsha's response held a teacher-centred belief that focused on measurable improvement on assessment for knowing that learners have developed content understanding.

Gatsha's beliefs about how learners learn science best. Gatsha's beliefs on how learners learn physical sciences best were categorised as instructive. He placed more emphasis on group work and responded:

> Learners engage in discussing activities, listening, and reading some of the work in class. They construct and create meaningful knowledge with the teacher interaction. Write activities in class in the form of classwork. Involve in a group discussion where they construct and create meaningful knowledge through discussion.

The focus of his response was based on learners' experiences, especially in group discussions. He revealed the activities learners do in the classroom, such as discussing and reading. There is the construction of knowledge by learners when involved in group discussions and collaboration. They interacted with each other as well as the teacher. Gatsha's belief was classified as teacher-centred.

Summary of Gatsha's teaching and learning beliefs. Table 8.1 profiles the overview of Gatsha's beliefs about physical sciences teaching and learning, which were overall coded as instructive.

Table 8.1

Summary of Gatsha's teaching and learning beliefs

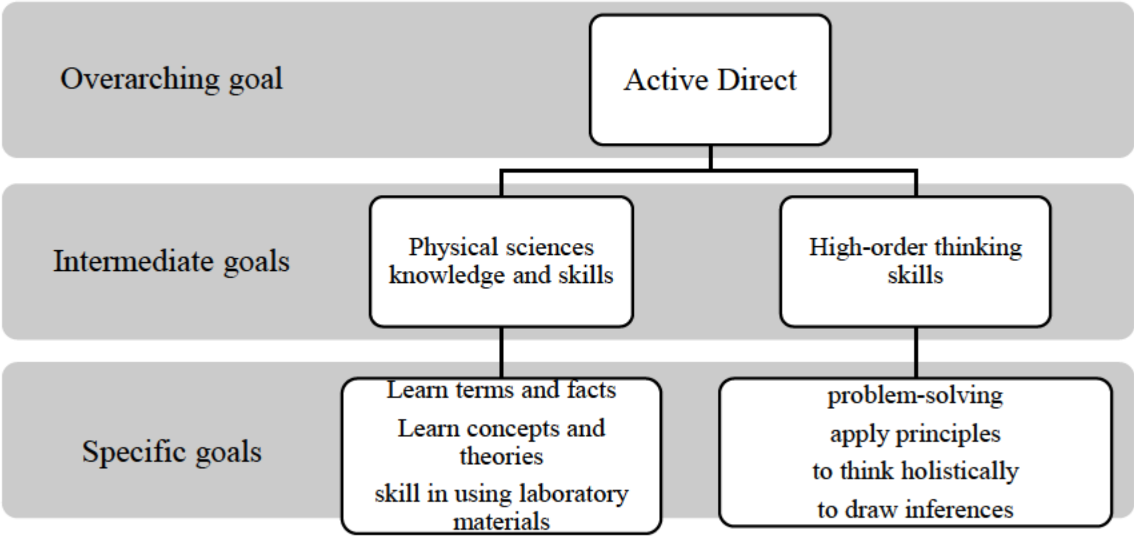
	QUESTION	RESULTS	REASON FOR CHOICE
TEACHING BELIEFS	How do you describe your role as a teacher?	Instructive	- I provide opportunities for learners to learn - I decide the activities learners will do in class - I create a conducive classroom environment
	How do you maximise learning for your learners?	Traditional	- I carefully planned the lesson - I manage the class in terms of distractions - I use different strategies and approaches
LEARNING BELIEFS	How do you know when learning is occurring in your class?	Instructive	- from their answers when given class activities - from their formal and informal assessment tasks
	How do you know your learners understand?	Instructive	-I monitor their answers during assessments - when they can answer correctly on the work done in class
	How do your learners learn science best?	Instructive	- working in a group in a class to solving problems - engage in class discussions

From the above analysis, I describe Gatsha as having teacher-centred, i.e., instructive beliefs. Firstly, Gatsha believed that he was a classroom manager, and to maximise learning, he needed to use different teaching strategies. Secondly, according to Gatsha, learning occurs when he monitors learners' answers through formal and informal assessments. Finally, even though he believed in learner participation, he regarded learners as consumers of knowledge.

Gatsha's goal system. Gatsha's goal system was developed and hierarchically arranged from his responses in POSTT (25 April 2019), TGI (30 April 2019), and SRI (18 August 2019). Figure 8.1 indicates a hierarchical arrangement of his goals. Gatsha's goals existed in a hierarchy with different levels of abstraction. The specific goals at the lowest level and the overarching (i.e., abstract) goal at the highest level. In between, there were two intermediate goals. Below, I detailed the analysis of each goal with sample responses.

Figure 8.1

Gatsha's goal system



Gatsha's overarching goal. Gatsha adopted an active direct overarching goal for physical sciences instruction. Explaining why he chose active direct to didactic direct, guided, and open inquiry, he explained:

> Active direct encourages active learning. Learners need to be active when they need to discover information on their own. That is one of my goals, to promote independent learning. I do believe that learners are not empty vessels and not tabula-rasa. They do know something. So, I need to allow them to think effectively and share information to come out with practical solutions and knowledge that will enable them to be better citizens of the country. Then the other reason is to expose learners to the technology we have. We live in a world advancing in technology, so learners need to be aware of the technologies used in our days (SRI, 18 August 2019).

For Gatsha, an active direct goal encourages learners to construct knowledge independently. Moreover, Gatsha wanted learners to develop an appreciation of scientific knowledge as they learn how things work in everyday life.

Gatsha's intermediate goals. Gatsha's two intermediate (mid-level) goals were: to equip learners with physical sciences knowledge and skills and to develop high-order thinking skills (TGI, 30 April 2019). Gatsha's first goal focused on helping learners understand physical sciences concepts through engagement in laboratory activities. Commenting on his goal to develop knowledge and skills, he said:

> As a novice teacher, my goal is to educate learners about practical skills and how they experiment to identify or figure out certain concepts in physical science (SRI, 18 August 2019).

Gatsha wanted to develop learners' laboratory skills so that learners could understand physical sciences concepts. Gatsha's goal was for learners to be able to conduct laboratory work in order to learn or discover physical sciences content.

Gatsha's second intermediate goal that he pursued was to help learners develop high-order thinking skills.

> The second one is to educate learners to be critical thinkers, solve things through their approach in analysing, and draw conclusions for specific physical sciences concepts. Another one is teaching physical science is how to do they inquire to identify information (SRI, 18 August 2019).

Gatsha emphasised that learners are critical thinkers to be able to figure out things on their own and do not depend on him as a teacher.

Gatsha's specific goals. Gatsha revealed specific goals that were essential in teaching and learning physical sciences under these two mid-level goals. Under the goal to develop physical sciences' knowledge and skills, the specific goals were to 'learn terms and facts, learn concepts and theories, skills in using laboratory materials, and graduate study' (TGI, 30 April 2019). When Gatsha justified his classroom actions, he mentioned different specific goals for different lessons.

During lesson one, they discussed and differentiated between kinetic and gravitational energy. When asked about his actions and behaviour during lesson one, he responded:

> We revised the topic on kinetic and gravitational potential energy during the lesson. Learners were supposed to differentiate between these two types of energies and apply the principle when doing calculations (SRI, 18 August 2019).

The focus for Gatsha was on the definitions of energies, how they differ, and solving problems involving them.

Gatsha emphasised the same goal for lessons two and three when they solve problems by applying the principle of conservation of mechanical energy. Gatsha elaborated on his goal and said:

> My goal was to assist learners in having an understanding of basic concepts of energy and calculations involved using the principle of conservation of energy (SRI, 18 August 2019).

For Gatsha, physical lesson four was the continuation of lessons two and three. This is how Gatsha explained what he desired for the lesson:

> Learners are supposed to learn appropriate concepts and theories. They must be able to apply the principle of conservation of mechanical energy and solve problems associated with it. I also encourage them to use scientific reasoning based on observations and calculations (SRI, 18 August 2019).

The above quotes indicate that Gatsha's specific goals focused on learners understanding physical sciences content knowledge and skills. He also emphasised the use of activities like laboratory work.

Summary of Gatsha's goals. Figure 8.1 indicates a hierarchical arrangement of Gatsha's goals with different levels of abstraction. During the SRI, he emphasised learning terms and facts and developing laboratory skills as the specific goals. He focused on achieving the intermediate goals of developing physical sciences knowledge and skills and developing high-order thinking skills. His overarching (i.e., abstract) goal was active and direct at the highest level. In Gatsha's case, the goals within his goal system were reinforcing. The progress towards maintaining the overarching goal resulted in the satisfaction of the intermediate goal and specific goals. For example, Gatsha's specific goal to develop learners' skills for using laboratory materials supported the intermediate goals of knowledge and skill, which supported the overarching goal for active direct. The intermediate goal that Gatsha explicitly focused on was developing learners' physical sciences knowledge and skills.

8.4 Teacher beliefs and goals in relation to IBI practices

The above discussion on research question one revealed Gatsha's teacher-centred beliefs and goals he pursued during classroom practices. Classroom practice findings were necessary to see how his beliefs and goals relate to his actions. In the following section, I firstly present findings for Gatsha classroom practice ratings. Gatsha's IBI classroom practices were rated using the EQUIP by Marshall et al. (2010). The EQUIP ratings will be followed by data analysis of Gatsha's mediating and goal representations in relation to his classroom practices. The EQUIP qualitative analysis was based on four-lesson observations: **Lesson 1**: Gravitational potential & Kinetic energy; **Lesson 2**: Mechanical energy (ME); **Lesson 3**: Conservation of mechanical energy; **Lesson 4**: Conservation of mechanical energy. This is followed below by the classroom practices discussion, where I provide data analysis responding to research question two on the relationship between beliefs and goals to classroom practices.

Classroom practices

Instructional factor. Gatsha was rated overall at the developing inquiry, i.e., level two on the instruction factor in all four lessons. Table 8.2 tabulates the rating for each construct under the instructional factor.

Table 8.2

Gatsha's EQUIP ratings: Instruction

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
	Instructional Strategies	2	2	2	2
	Order of Instruction	2	2	2	2
Instructional factor	Teacher Role	2	2	2	2
	Learners' role	2	2	2	2
	Knowledge acquisition	2	2	2	2
Overall		**2**	**2**	**2**	**2**

Level two, developing inquiry, means that generally, instructional activities were teacher-centred, and Gatsha rarely acted as a facilitator to the learning of physical sciences content. Gatsha's instructional practices heavily focused on mastery of the content of the physical sciences. Learners were minimally active, answering questions and completing activities related to calculations. He lectured most of the time but engaged learners in activities that helped them understand the concepts by asking questions and explaining. Gatsha interacted with learners to ensure that they were active. He asked learners the definitions of concepts such as, 'what is energy?' and 'can you differentiate between potential kinetic energy?' He then allowed learners to respond before probing further if necessary and explaining the concepts. There were no questions that emerged from learners for further class discussion. However, learners were minimally active in answering oral questions and doing the calculations on the chalkboard. He used examples and calculations from the booklet with previous question papers that helped develop an understanding of the content of the physical sciences. Gatsha acted as a facilitator at a minimal level. Gatsha was the one that initiated the interaction between himself and the learners.

Discourse factor. Gatsha's summative rating was again at level 2 for the discourse factor, which is basically the teacher and learner-centred classroom practices. Table 8.3 tabulates the rating for each construct under the discourse factor.

Table 8.3

Gatsha's EQUIP ratings: Discourse

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
	Questioning level	2	2	2	2
	Complexity of questions	2	2	2	2
	Questioning ecology	2	2	2	2
Discourse factor	Communication pattern	2	2	2	2
	Classroom interaction	2	2	2	2
OVERALL		**2**	**2**	**2**	**2**

Level two for discourse factor indicated that, though present, Gatsha's questioning and discussions were not at the required level, and learning activities lacked opportunities for critical thinking. The four lessons focused on mastery of facts and some routine problem-solving skills. Gatsha asked questions that focused on developing learners' understanding. Even though the questions varied, they concentrated on lower-level understanding, such as the definition of gravitational potential energy, stating the law of conservation of energy, and calculations. Gatsha also used questions from the textbook and previous question papers. Even the questions from the textbook and the booklet seemed not to facilitate high-order thinking skills. In most cases, Gatsha facilitated the classroom discussion, yet the teacher-learner discourse was often conversational.

Assessment factor. Gatsha was overall rated at level 2, developing inquiry for assessment factors associated with IBI. Table 8.4 tabulates the rating for each construct under the assessment factor.

Table 8.4

Gatsha's EQUIP ratings: Assessment

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
	Prior Knowledge	2	2	2	2
	Conceptual Development	2	2	2	2
Assessment factor	Learner Reflection	1	1	1	1
	Assessment Type	2	2	2	2
	Role of Assessing	2	2	2	2
OVERALL		**2**	**2**	**2**	**2**

The developing inquiry level of teachers' assessments means that Gatsha's formal or informal assessments measured factual knowledge, and little attention was placed on using authentic assessments. Gatsha scored lowest for the reflection indicator because he did not prompt learners to reflect on their learning in all four lessons. During the lesson's introduction, Gatsha recapped the previous lesson by asking questions and assumed he assessed the learners' prior knowledge. The informal assessment was occasionally utilised during the lessons, and most of the questions asked were at a lower level, requiring recall, restating, and explaining. The questions for calculating the conservation of mechanical energy involved routine problem-solving. The role of assessment focused on soliciting the correct responses from learners. Most informal assessment activities involved oral questions, paper and pencil assessing factual knowledge, and a low understanding level.

Curriculum factor. Gatsha was overall rated at level two, developing inquiry for curriculum factors associated with IBI. Table 8.5 tabulates the rating for each construct under the assessment factor for all four lessons.

Table 8.5

Gatsha's EQUIP ratings: Curriculum

Factors associated with IBI	Construct	Lesson 1	Lesson 2	Lesson 3	Lesson 4
	Content depth	2	2	2	2
	Learner Centrality	2	2	2	2

	Integration of Content and Inquiry.	1	1	1	1
Curriculum factors	Organizing & Recording of Information	2	2	2	2
OVERALL		**2**	**2**	**2**	**2**

Level two for curriculum factors indicated that Gatsha's lessons had an inadequate depth to the content covered, and activities planned for the learners were not adequately focused on inquiry. It was not easy to discern the level of this factor because learners did not engage in any practical activities during the four lessons observed. The physical sciences content taught allowed the investigation to be integrated with content; however, all the lessons were content-focused with no inquiry present. However, Gatsha did practice some inquiry attributes during the lessons. For example, the lessons' content depth was at developing inquiry since Gatsha made a point of connecting the discussion on gravitational potential energy, kinetic energy, and mechanical energy to the big picture, using practical examples of real-world situations. He used various ways to engage learners, like visual demonstrations of these different types of energies.

Classroom practices summary: Using EQUIP instrument, Gatsha's IBI classroom practices overall rating was at level two, i.e., developing inquiry level for all the constructs (instruction, discourse, assessment, and curriculum) as indicated in Table 8.6.

Table 8.6

Gatsha EQUIP ratings

IBI factor	Instructional	Discourse	Assessment	Curriculum	Overall IBI
Level	2	2	2	2	2 - Developing

Gatsha scored level two in all his lessons, and there was no indication of moving towards level three. Developing inquiry is characterised by traditional classroom practices that are learner-directed. In the traditional classroom, Gatsha engaged learners with activities related to the concept, which, however, did not require learners to think deeply about the material.

Gatsha's teaching and learning beliefs and IBI practices. Gatsha was described as having teacher-centred, i.e., instructive teaching and learning beliefs under section 8.3 analysis. Under Section 8.4, Gatsha's classroom practices were rated at level two, developing inquiry. This section revealed how Gatsha's teaching and learning beliefs and goals relate to his classroom practices.

Gatsha's beliefs about the role of the teacher were instructive. He believed in creating learning opportunities and choosing activities for learners. His role was teacher-focused. I observed that his learners were comfortable with him, creating a conducive learning environment and not having class management issues. During classroom practices, Gatsha took the leading role in teaching but encouraged learner participation.

Gatsha believed that learning could be maximised if he used different activities to engage learners. His response focused mainly on his activities instead of learners' activities. During the instruction, he had prepared lesson plans and taught according to what he had prepared. However, during the four lessons I observed, learners did not investigate any concepts or conduct laboratory experiments. Gatsha demonstrated the difference between gravitational potential and kinetic energy. He was able to motivate and keep learners involved during the lessons.

Gatsha had instructive beliefs about determining when learning was occurring, and he focused on his learners' achievements and responses during assessment tasks. He believed that if learners gave correct answers learning occurs. During classroom practices, he gave learners classroom activities and homework. He used both formal and informal assessment tasks to solicit learners' understanding of concepts. Some class assessment tasks were controlled with learners to monitor their responses and he assumed they had learned the concept.

Gatsha had instructive beliefs on determining how learners understand physical sciences concepts. He believed that when learners answer questions correctly after teaching the concept and do not ask follow-up questions, they understand it. His lessons involved the definition of terms and calculations based on kinetic energy, gravitational potential energy, and solving problems in mechanical energy. He gave learners a problem and monitored whether they could solve them. Gatsha demonstrated instructive beliefs during classroom practices.

Gatsha believed that learners learn science best when working and solving problems in a group and engaging in class discussions. During classroom practices, I observed Gatsha encouraging group discussions. Learners worked in groups to solve mechanical energy problems before reporting to the whole class and writing solutions on the board.

Gatsha's goal system and IBI practices. Gatsha reinforced the specific goals for lessons one to four to the intermediate goal of developing physical sciences knowledge and skills. I observed during the lessons Gatsha asked learners to define and differentiate between terms and concepts. He presented lessons mainly through lectures and involved learners by asking questions and discussing. If learners could define terms and state the law, he assumed they had learned. Even though Gatsha mentioned that he sometimes conducts practical work, the purpose of employing it was to have learners verify science concepts taught during the lesson. Gatsha's specific goals reinforce the intermediate goal of developing physical sciences knowledge and skills. Furthermore, Gatsha adopted an overarching goal of using active direct in the teaching and learning of physical sciences. It appeared that Gatsha's desire for active direct was closely related to his teaching and learning beliefs. Moreover, Gatsha maintained the active direct goal through intermediate and specific goals during classroom practices. Therefore, I observed the alignment (direct relationship) between Gatsha's actions and goals.

In summary, Gatsha's teaching and learning beliefs were categorised as teacher-centred. But they were instructive beliefs because they involved some learner participation. Gatsha's learners did not conduct any laboratory experiments during classroom observations, but his lessons had some IBI characteristics. Gatsha was rated at the developing inquiry level, and his beliefs as instructive. There was a direct relationship between Gatsha's classroom practices and his teaching and learning beliefs. Furthermore, Gatsha's specific goals were reflected in his actions during classroom practices and reinforced the achievement of his overarching goal. The goal of using active direct is aligned with Gatsha's classroom practices and is rated as developing inquiry.

8.5 The influences on teacher beliefs, goals, and IBI practices

This section provides a synthesized analysis that combines the findings from Gatsha's teaching and learning beliefs and goals that guided his classroom practices.

Beliefs and goals. Gatsha's instructive beliefs about teaching aligned with his classroom practices at developing inquiry, which uses both teacher and learner-centred instruction. Gatsha believed that maximising physical sciences learning was about what he was doing in class, not about what learners contribute to the learning environment. He focused mainly on what he must do or give to his learners. What surfaced during the four lessons is that Gatsha did most of the explaining and making the connections for the learners. Learners did not explore the concepts in the four lessons. He taught and solved calculations on the conservation of mechanical energy in a structured way. However, he provided an opportunity for learning by allowing learners to solve problems on their own. He frequently lectured but used the demonstration to explain gravitational and kinetic energy concepts as he believed in using different activities to cater for diverse learners. Gatsha's instructive beliefs about IBI aligned with his classroom practices at the developing inquiry. Gatsha believed in direct teaching and learning and using questions to gauge learners' understanding.

Social and physical context. Gatsha indicated some physical and social context that he is teaching under that support and does not support his IBI. During the SRI (18 August 2019), he mentioned that his school was not well resourced. There was no sciences laboratory, and they had to use the resource centre (i.e., CASME) to conduct practical work. On the issues of departmental officials (Subject Education Specialist (SES) exerting pressure, he commented:

> One of the demands is that they want all learners to pass physical sciences. For example, they want our learners to excel in their performance in the physical sciences. There is a history of poor performance in subjects like physical sciences, mainly in all schools within our district. So, they want us to produce good results. They emphasise that most higher education careers require physical sciences as a subject. So, learners need to have good physical science results. They suggest that for each school, the pass rate for physical sciences subjects must be above 65% in grade 12 (SRI, 18 August 2019).

Furthermore, he commented on support from SES, indicating that 'they (SES) are not giving us enough support as novice teachers. As teachers, we do not have enough resources that we can use. There are enough workshops to equip us as novice teachers' (SRI, 18 August 2019).

On the issue of time constraints, he explained:

> Time was the factor. We have like 60 minutes for a period. The guided inquiry will take a lot of time. Due to time constraints, I used active direct and explained to learners. I also gave them some activities from the department's textbook examination guidelines (SRI, 18 August 2019).

Gatsha felt that the physical sciences curriculum contained too many topics that needed to be taught within a specific period, which sometimes compelled him to use active direct to cover the work.

However, Gatsha indicated some social and physical factors that support his classroom practices. He mentioned that he used and followed the annual teaching plan (ATP), CAPS document, and the examination guidelines when planning to teach. According to Gatsha, these documents were helpful even though they specified what to teach and not how to teach. Moreover, the grade 10 physical sciences learners had a booklet with the previous examination question papers. He used that booklet to supplement the activities given in the textbooks. He seemed to like and value the book as useful. He explained:

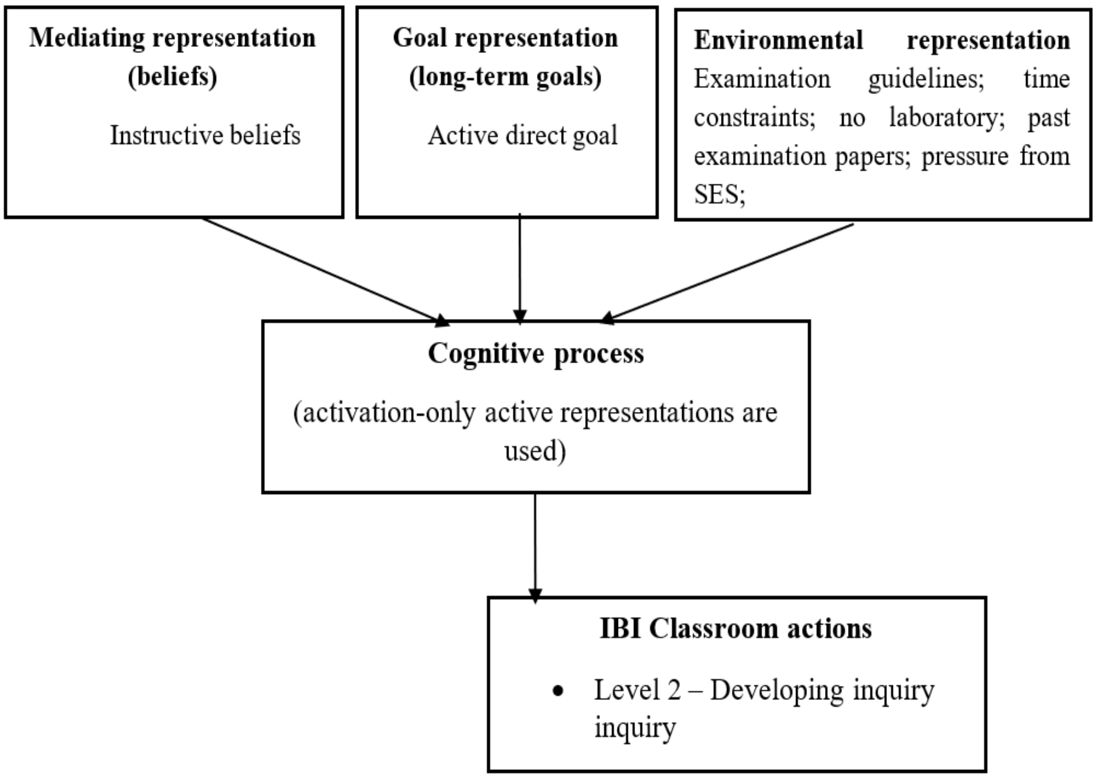
> That booklet has questions from previous question papers. These assist learners in being aware of how questions will be asked in the examination. Some of those questions are high order and not like in the textbook, so they practice those questions to tackle the examination (SRI, 18 August 2019).

8.6 Summary of findings

This chapter detailed Gatsha's teaching and learning beliefs, the goals he pursued, and the IBI level during classroom practices. Figure 8.2 summarizes Gatsha's findings, as explained in this chapter.

Figure 8.2

Gatsha's beliefs, goals, and environmental representations summary



Gatsha held responsive teaching and learning beliefs. He adopted an overarching goal of active direct. The environmental factor that supported his classroom practices was the booklet with previous question papers he received from SES. He did not have a science laboratory in his school, which constrained the conducting of experiments. Also, the pressure from district SES constrained his teaching as he focused more on preparing learners for examinations. The interpretation of these findings is discussed in chapter nine.

CHAPTER NINE
INTERPRETATION AND DISCUSSION OF RESULTS

9.1 Introduction

This qualitative multiple-case study explored the relationship between novice physical sciences teachers' beliefs and goals to IBI practices. The main purpose of this study was to understand how novice teachers' beliefs and goals influence classroom practices in the context of IBI. Many research studies have focused on identifying the relationship between teacher beliefs, goals, and classroom practices and the factors contributing to that relationship. The gaps still exist in the literature regarding the role played by these mental constructs, beliefs, and goals during classroom practices. Studies in science education have explored the relationship between beliefs and classroom practices (Hutner & Markman, 2017; Lebak, 2015; Luft, 2009; Luft et al., 2015; Ozel & Luft, 2013; Wong et al., 2015). However, the consistencies and inconsistencies observed between science teachers' beliefs and their classroom practices have made it difficult to delineate the relationship between science teachers' beliefs and classroom practices. The beliefs-practice (in)consistency paradox has prompted the push of boundaries to explore the role of science teachers' goals in their classroom practices. Therefore, this study explored the relationship between four novice physical sciences teachers' beliefs and goals to their IBI practices.

In chapters five, six, seven, and eight, each case was described in detail in terms of background and classroom context, teaching and learning beliefs, teaching goals, classroom practices, and their relationship. This chapter provides a summary of the findings from these four chapters, along with their interpretations. I also support the findings and interpretations with the literature review and theoretical framework.

The primary research question for this study is:

What is the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices?

This question was addressed by researching three sub-questions discussed in the following sections.

9.2 Teachers' beliefs and goals about IBI

The first sub-question was:

What beliefs and goals do novice physical sciences teachers hold about IBI?

The stability of beliefs assumption indicates that some novice teachers' beliefs are less stable and less resistant to change. Therefore, I thought it was appropriate to determine the nature of novice teachers' teaching and learning beliefs. Guided by the constructivist theory, I then posit whether these beliefs are teacher or learner-centred. The findings from research question one were the initial step to determining the relationship between beliefs and IBI practices. The thinking was that novice physical sciences teachers with learner-centred beliefs would more likely engage in IBI practices, and those with teacher-centred beliefs will not. This first research question was intended to understand explicitly the novice physical sciences teachers teaching and learning beliefs.

Beliefs. The analysis revealed that novice physical sciences teachers expressed teaching and learning beliefs that were predominately teacher-centred. Three novice teachers had teacher-centred beliefs varying from traditional to instructive. One novice teacher had learner-centred teaching and learning beliefs. Table 9.1 shows the distribution of novice physical sciences teachers' beliefs about teaching and learning. Nelisa held responsive beliefs, Amalia and Gatsha both had instructive beliefs, and Wayde had traditional beliefs.

Table 9.1

Overall teaching and learning beliefs

	Teacher-centred			**Learner-centred**	
	Traditional	Instructive	Transitional	Responsive	Reform-based
Nelisa				**X**	
Wayde	**X**				
Amalia		**X**			
Gatsha		**X**			

The data pattern in Table 9.1 indicates that Wayde, Amalia, and Gatsha, held teacher-centred beliefs, while Nelisa held learner-centred teaching and learning beliefs. Considering Mansour's (2009, 2013) discussion about the nature of beliefs, these study findings reflect similar findings. Mansour explored the nature of teaching and learning teachers' beliefs and agreed that they are extremely varied. The teacher-centred beliefs held by Amalia, Gatsha, and Wayde are the predominant beliefs about the role of a teacher as an expert in knowledge production and presenting such knowledge directly to learners in a logical sequence. Wayde believed in engaging learners in lecture teaching, knowledge transmitting, rote learning of scientific facts, and a passive role for the learner. Amalia and Gatsha held instructive beliefs because their teaching and learning beliefs focused on them as the main source of knowledge, with some attention given to learners' participation in the lessons. Nelisa's learner-centred belief was based on the fact that individuals construct knowledge and that the role of the teacher is to be a facilitator who allows learners to reconstruct, extend or replace their existing knowledge. Nelisa's teaching and learning beliefs were coded as responsive because her focus was on learners' construction of knowledge, and she played a role of a facilitator. Overall, the teaching and learning beliefs exhibited were mostly teacher-centred and unfavourable towards IBI practices.

For example, in this study, novice physical sciences teachers' beliefs about maximising learning and how learners learn appeared to be shaped by their current school and classroom layout context. Firstly, the classroom organisation revealed assumptions about their teaching and learning beliefs. For example, Wayde, who articulated traditional beliefs, taught in a class with traditionally arranged desks with long rows of learners that faced the teacher's table and chalkboard. The learners' seating arrangement was consistent with the perception of a teacher who is a knowledge transmitter. All his lessons were taught in the classroom. He never used the science laboratory, nor did he ever use any learning resources, even though some were available at the school. He based all his lessons on the textbook and worksheets. Wayde viewed himself as the one with authority in teaching physical sciences and saw the learners as uniformed recipients of knowledge.

Amalia used the traditional arranged classroom and the science laboratory when the lesson required practical work. Her learners had access to resources like laptops when doing PhET simulations. Amalia's use of the science laboratory and PhET simulations revealed her desire to involve learners in hands-on activities. Gatsha taught in a traditionally arranged classroom. He also believed in hands-on activities and took his learners to the resource centre for practical work. Contrary to Nelisa, who articulated responsive beliefs and taught in the science laboratory, even if they were not doing any practical work for the lesson. The seating arrangement in the small group displayed learners' collaboration when learning science. The physical layout of their classrooms possibly explained why they held such beliefs about teaching and learning. Nelisa believed in being a facilitator, allowing learners to collaborate and take responsibility for their learning. Compared to Nelisa, Wayde believed in knowledge transmission and providing information in a structured way. The results from this study support the assumption that the beliefs of many science teachers may stem and be influenced by classroom layout (Buehl & Beck, 2015; Hutner & Markman, 2017).

When studying teaching and learning beliefs, it is essential to take into consideration different contextual factors that shape teachers' beliefs. The literature indicated that sciences teachers interpret the policy inputs in ways that are influenced by and consistent with their currently held belief sets. For instance, teachers' beliefs influence how they respond to particular policies intended to change teachers' practices (Anderson, 2012; Hutner, 2015). In this study, novice physical sciences teachers differ in their choice of curriculum material. Nelisa, Amalia, and Gatsha mentioned that they use an annual teaching plan to check their progress on content coverage. They also use examination guidelines to check how learners should answer questions during examinations. Amalia and Gatsha also used the DBE textbook with previous question papers for grade 10 learners. They believed that this book prepared learners for common testing and examinations. Nelisa added that she engaged with the CAPS document for lesson preparation because it gave her guidance on what should be covered in a lesson. Nelisa was the only teacher who stressed the importance of using the CAPS documents in conjunction with other resources. Amalia, contrary to Nelisa, mentioned that she relied more on the previous question papers and guidance from SES than the CAPS document. One of the claims from this study is that the adoption of these curriculum materials, excluding CAPS, explained why Amalia and Gatsha had instructive beliefs about how learners understand physical science content, contrary to Nelisa, who used CAPS and believed learners must apply content knowledge in new situations. This study's results are consistent with Li et al.'s (2006) findings. They mentioned that some teachers would not use curricular materials if they believed that the curricular activities would not prepare learners to do well on standardized tests for which schools were held accountable.

District official SES seemed to have a measure of control over what happens in the physical sciences classroom. Nelisa and Gatsha verbalised the pressure of producing the best common tests and examination results they received from the district SES. The district SES put more emphasis on increasing the pass rate in physical sciences. The grades 10 to 12 wrote common quarterly tests and examinations. District SES focused more on common tests and examination of learners' performance than conceptual understanding. Even though Nelisa expressed that she was subjected to the same pressure from the district SES, she revealed responsive beliefs that encourage learners to apply the content learned to a new situation for understanding. Amalia and Gatsha's focus was that learners could reiterate what has been learned in the classroom and repeat correct answers during tests and examinations. As a result, they used the book from DBE with previous question papers to drill learners. Even though he had not felt the pressure from district SES, Wayde revealed traditional beliefs as his lessons focused on repeating the content more than once for learners to understand. The social factor from departmental SES, who emphasised content coverage at the CAPS policy's expense to teach science as the inquiry, may have influenced novice teachers' beliefs. The study findings are similar to Levin et al.'s (2013) findings that beginning teachers abandoned their enthusiasm for differentiated learning because it conflicted with school norms that emphasised drilling students using past examination items in preparation for high-stakes examinations. The policy of common testing (i.e., standardised tests) and examinations influenced novice physical sciences teachers' beliefs.

The environmental factor of teaching experience seemed to shape teacher-centred teaching and learning beliefs. The teaching experience, i.e., novice teachers' number of years teaching physical sciences, was one factor I assumed impacted their teaching and learning beliefs. Wayde had the least amount of physical sciences teaching experience, one year, and had more traditional beliefs than the other three. Amalia and Gatsha had three years of teaching experience and instructive beliefs, with Nelisa having four years of teaching experience and responsive beliefs. This analysis may establish how the teaching and learning beliefs may become more teacher or learner-centred with increasing years of science teaching experience. Fletcher and Luft (2011) suggested that some of the reasons beliefs shift are caused by facing situations such as static school culture, little support from school leaders for implementing reform-based strategies, and the new teachers' feelings of being overwhelmed. The claim of being overwhelmed is a factor that aligned with Wayde's case in this study. During data gathering, it was Wayde's first year teaching physical sciences. He also taught grade ten life sciences and technology in grades eight and nine. Wayde felt overwhelmed as he complained about the teaching workload, preparation, and marking. Additionally, he did not mention any support from the sciences' head of department and school. As a novice teacher, lack of support and overloading may have caused Wayde to reveal traditional beliefs. Luft and Roehrig (2007) argued that beliefs formed by science methods courses during teacher preparation programs are less resistant to change and more likely to change than those of experienced teachers.

Professional development programs are recommended to enable teachers to adopt learner-centred beliefs. At the data gathering time, Nelisa, Amalia, and Gatsha were studying for their B.Ed. Honours (Science and Mathematics) degree for professional development and they attended a couple of workshops to develop physical sciences content organised by the district SES. Moreover, Nelisa and Amalia mentioned that they were getting support from district SES workshops during school visitations. Wayde was not studying during data gathering and had not yet attended any physical sciences workshop organised by district SES. These findings suggest that the support from the B.Ed. programme and district content workshop may have shifted their beliefs from traditional to instructive and responsive. Similar to studies by Luft et al. (2011) and Wong et al. (2013), subject-specific induction and mentoring support was critical to fostering beginning secondary science teachers' implementation of IBI and developing more learner-centred beliefs. There is a possibility that for Nelisa, Amalia, and Gatsha, furthering their studies and attending district workshops assisted them in moving toward learner-centred beliefs.

Considering that novice physical sciences teachers had recently graduated from a teacher education institution, these findings may seem surprising. However, their teacher education experiences were more recent and obviously more relevant to their practices as science teachers. Even though this study did not establish where novice teachers' beliefs stemmed from, the assumption was that they still hold teaching and learning beliefs from their teacher education. Their teacher education includes four years of pedagogical training, especially in adopting learner-centred instructional practices. The knowledge gained during teacher education should form a significant aspect of novice teachers' beliefs. Hence one assumed that these beliefs regarding science teaching and learning might actually favour the IBI practices learned during teacher education. In this instance, the findings align with Belo et al. (2014), who argued that novice teachers' beliefs are less stable and less resistant to change when compared to experienced teachers. Furthermore, Saka et al.'s (2013) study established the power of context, i.e., school administrators, peer teachers, learners, and classroom designs, that compel novice teachers to abandon the reform-based practices they acquired during teacher education.

Goals. Each novice physical sciences teacher had a goal to implement some level of IBI in their practices. Table 9.2 presents the distribution of novice physical sciences teachers' overarching goals about IBI. Wayde, Amalia, and Gatsha had the same overarching goal of teaching physical sciences using active direct, and Nelisa had the one to use guided inquiry.

Table 9.2

Overarching goals

	Teacher-focused		**Learner-focused**	
	Didactic direct	Active direct	Guided inquiry	Open inquiry
Nelisa			X	
Wayde		X		
Amalia		X		
Gatsha		X		

From Table 9.2, Amalia, Gatsha, and Wayde had a teacher-focused goal of having learners be active with materials or "hands-on" experiences (Magnusson et al., 1999). Nelisa had a learner-focused goal that constitutes a community of learners whose members share responsibility for understanding the physical world, particularly with respect to using science tools (ibid). Additionally, in this study, no teacher had an open inquiry goal. This finding aligns with Ladachart's (2019) study, illuminating that pre-service sciences teachers tended to have orientations between active direct and guided inquiry on average. Also, Park and Chen (2012) found that teachers' orientations toward teaching science were mainly between didactic and guided inquiry. One seldom finds teachers with an open inquiry orientation. Feyzioglu's (2015) research supported these findings indicating that pre-service teachers' pedagogical orientation never reached the open inquiry level. Again, the findings of this study were not consistent with the study result by Karal (2017), who found that more than half of the physics student teachers displayed learner-centred orientations.

The hierarchical approach revealed multiple goals that were not isolated but related to novice physical teachers in this study. The pattern (see figures 5.1, 5.2; 5.3 & 5.4) revealed that the four novice physical sciences teachers had the same intermediate goals, with Wayde differing from one. They all had an intermediate goal to develop physical sciences knowledge and skills. The second goal, the same for the others except for Wayde, was to develop high-order thinking skills. Wayde's second intermediate goal was to develop work and career preparation skills.

The specific goals they articulated during SRI were for learners to learn terms and facts, concepts and theories, and develop skills in using laboratory materials related to the intermediate goal of developing science knowledge and skills. The specific goals related to developing high-order thinking skills are problem-solving, applying principles, and drawing inferences. From their studies, Barendsen and Henze (2019) and Kang (2008) documented goals identical to goals adopted by novice teachers in this study. Chiappetta and Adams (2004) and Honebein (1996) emphasized that inquiry-based science instruction should promote the understanding of fundamental facts, concepts, principles, laws, and theories; and develop skills that enhance the acquisition of knowledge and understanding of natural phenomena. In this study, all novice teachers emphasised these IBI goals but differ in their classroom actions when pursuing them.

Like beliefs, the context influences goals and subsequent actions science teachers take to satisfy their goals in multiple ways (Hutner et al., 2021). The school context played a role in influencing novice teachers' goals adoption, which they articulate or manifest during teaching. In this study, Gatsha came from a poorly resourced, disadvantaged township school. For example, in Gatsha's case, he did not have a science laboratory, and class sizes were bigger regarding the number of learners. The school context may have influenced him to adopt an active direct goal even though he indicated he desired active engagement with learners. Contrary to Nelisa, who came from a township school with resources, a science laboratory enabled her to engage learners in practical activities. She also used learning resources such as projectors and the physical sciences app. Nelisa adopted a guided-inquiry goal and indicated that her desire was for her learners to develop knowledge and skills in physical sciences. However, Nelisa being in a township school did not stop her desire to teach using guided inquiry. Amalia and Wayde were from 'ex-model C' schools with resources, but both adopted active direct goals. Wayde did not use the available resources, whereas Amalia used them occasionally. In comparison, Ramnarain and Schuster (2014) found that science teachers at disadvantaged township schools have a strong, active direct orientation, while those at suburban schools exhibit a guided inquiry orientation. It was not a conclusive case for this study as Nelisa was from a township school but adopted a guided inquiry goal. Both Amalia and Wayde adopted active direct goals with all available resources. Considering the goal adoption, Sondlo and Ramnarain's (2018, 2021) studies indicated environmental factors such as the number of learners, time constraints, availability of resources, and curriculum goals impact science teachers' orientations.

In this study, Nelisa mentioned that she had developed a friendly teaching and learning environment with her grade 12 learners since she started teaching them in grade 10. This was Nelisa's third year with the same learners in her four years of teaching. This factor may have assisted Nelisa in adopting a guided inquiry goal. Amalia and Gatsha taught grade 10, and it was their first encounter in this grade. It was also Wayde's first grade 10 experience and he was now teaching grade 11 for the first time. A friendly classroom environment, being a facilitator, may influence goal adoption for novice teachers. This finding supported Avraamidou's (2013) study that teachers' characteristics and a friendly classroom environment were among the important ways to develop their science teaching orientations.

In summary, the novice physical sciences teachers' teaching and learning' beliefs manifested were teacher-centred for Amalia, Wayde, and Gatsha and learner-centred for Nelisa. Like overarching goals, Amalia, Wayde, and Gatsha had teacher-focused goals, whereas Nelisa had learner-focused goals. The findings from this study suggested that environmental factors, whether social or physical, can reinforce the nature of teaching and learning beliefs and influence goal adoption that manifest within teachers. The physical influences of novice teachers' teaching and learning beliefs and goal adoption were school context (i.e., classroom layout), large class size, availability of resources (e.g., laboratories), curriculum materials, standardised testing, and examinations. The social influence was from the departmental SES.

9.3 Teachers' beliefs and goals in relation to IBI practices

The second sub-question was:

How do novice physical sciences teachers' beliefs and goals relate to their IBI practices?

The purpose of this analysis was to explore how the novice physical sciences teachers' beliefs and goals expressed in question one relate to their IBI practices. I wanted to understand how novice teachers' beliefs and goals influence classroom practices. I determined the relationship between teaching and learning beliefs and overarching goals to IBI classroom practices. The initial step to answering this question was to determine novice teachers' level of IBI. This section interprets the IBI implemented level and then discusses the relationship between beliefs and goals to IBI practices.

IBI practices. The findings concluded that novice physical sciences teachers explored in this study operated at low inquiry levels during classroom practices. Three novice teachers' IBI practices were teacher-centred. Wayde's classroom practices were rated at the pre-inquiry level and Amalia and Gatsha at the Developing Inquiry level. Nelisa was the only novice teacher who enacted IBI at the Proficient Inquiry level, learner-centred. Wayde's instruction was more traditional and content-focused. He traditionally taught physical sciences content and focused on drilling the content and vocabulary while learners were passive. Gatsha and Amalia's instruction was teacher-centred, but they incorporated inquiry-based activities into their practices through learner involvement and hands-on activities. They used didactic methods to ensure that the learners learned the required physical sciences content. Amalia's school environment allowed her to use the science laboratory for experiments and PhET simulation. Gatsha did not have a laboratory, but he used demonstration and questions to drive developing inquiry learning. Nelisa used IBI. Her focus was on ensuring that learners could think critically and develop inquiry skills. She was fortunate to teach in the science laboratory, so her classroom environment was always set up to support inquiry-based learning. An additional finding was that none of this study's novice physical sciences teachers identified as Exemplary Inquiry teachers.

These findings support the concerns mentioned in chapter one of this study that physical sciences teachers relied more on traditional instructions, and IBI is practiced at low levels. Additionally, they support the research that the majority of science teachers do not engage in proficient or exemplary IBI (Capps & Crawford, 2013; Marshall et al., 2011) despite the fact that IBI has demonstrated utility in achieving science teaching and learning (Kang & Keinonen, 2018; Marshall & Alston, 2014). The findings from this study support the previous studies' results. Crawford (2014) regards inquiry-based pedagogy as a complex and sophisticated way of teaching that demands significant professional development. Ozel and Luft's (2013) study findings confirmed that beginning science teachers tended to align with more teacher-centred approaches and were limited in enacting inquiry in the classroom. Nordine et al. (2021) agree that new teachers struggle to implement the pedagogical tools and strategies they learned in pre-service science teacher education and often adopt more traditional instructional methods. Moreover, Crawford and Capps (2018) argue that most teachers hold limited views of inquiry-based instruction and the nature of science in general and these views are reflected in their teaching practices.

The findings are not surprising considering the poor performance in physical sciences education, as mentioned in chapter one of this study. In South Africa, IBI has been advocated in physical sciences education as a teaching pedagogy that facilitates critical, deep thinking and can promote meaningful understanding of science concepts in learners, hence improving science education (DBE, 2011; Dudu, 2014; Mokiwa, 2014; Ramnarain & Hlatswayo, 2018). The findings from this study provided evidence of the traditional teaching dominance in science classrooms. Studies from South Africa reveal that instruction is still teacher-centred, and the emphasis is placed on the transmission of scientific knowledge (Dudu, 2014; 2014; Ramnarain et al., 2016). These findings are also similar to many studies worldwide, even in developed countries such as the US, UK, Australia, and Canada, that explored the level of IBI practices by teachers in school science. For example, in the US, Capps and Crawford (2013) found little evidence of inquiry in classrooms of even highly motivated, well-qualified science teachers.

Even the use of IBI is attributed to physical and social factors. Grade levels are mentioned as one of the underlying factors that may influence teacher implementation of constructivist classroom practices (Savasci & Berlin, 2012). At the time of data gathering during classroom observations, Nelisa was teaching grade 12, Wayde was teaching grade 11, and both Amalia and Gatsha were teaching grade 10 learners. Savasci and Berlin (2012) claimed that teachers in lower grades might use more constructivist-like, learner-centred activities such as concrete, hands-on activities to reflect the developmental level of their students. Teachers in middle schools may employ a more developmental, constructivist, learner-centred approach to teaching science to respond to the needs and interests of middle school learners. Teachers in high schools may employ a more content-focused, teacher-centred approach reflective of their goals and beliefs in transmission, efficiency, rigor, and examination preparation. In contrast to Savasci and Berlin's findings, Nelisa was the only novice teacher teaching grade 12 and employed a constructivist, learner-centred approach to teaching science. All three novice physical sciences teachers employed a traditional, teacher-centred approach.

Nelisa and Gatsha's school science schooling experience did not have opportunities to hands-on methods and laboratory until later at university, where they had laboratory learning experiences. As a result, Gatsha did not want his schooling experience to impact his learners' performance in learning sciences. He demonstrated a desire to move past the traditional teaching approach and engage learners in hands-on experiences. He mentioned that he organised for learners to go to a local science centre for practical activities since his school had no science laboratory. Even though Nelisa had a schooling experience like Gatsha, she was fortunate that she taught in the science laboratory and could engage her learners in hands-on and mind-on activities. Though Amalia and Wayde did not mention their past schooling experience, Amalia used PhET simulation, most likely learnt from education modules, to engage learners. This pattern demonstrated their desire to move past the traditional teaching method to IBI even without resources. Ramnarain (2016) argues that intrinsic and extrinsic factors of science teachers affect the implementation of inquiry-based learning, which is consistent with the study's findings.

Aydeniz and Southerland (2012) opined that teachers are pressured to focus on using traditional instructional and assessment practices that effectively improve learners' achievement scores. In this study, as indicated in the belief section 9.2, Nelisa, Gatsha, and Amalia mentioned the pressure they received from district SES to improve their pass performance in physical sciences. As a result, Nelisa used examination guidelines, and Amalia and Gatsha used previous question papers to drill learners to answer questions during assessment tasks. There was an influence on science teachers to adopt certain curricular materials that impacted their instructional strategies. Capps et al. (2016) also agree that US teachers are routinely prevented from using inquiry-based instruction due to time constraints resulting from high-stakes testing programmes. Capps et al.'s concerns are similar to the current South African situation that is exam orientated.

The relationship between teachers' beliefs and goals to IBI practices. Table 9.3 indicates how novice physical sciences teachers' beliefs and goals relate to IBI practices.

Table 9.3

Summary of Beliefs and Goals to classroom practices

Novice teachers	Beliefs	Goals	Classroom Practices
Nelisa	Responsive	Guided inquiry	Level 3 - Proficient
Wayde	Traditional	Active direct	Level 1 - Pre-inquiry
Amalia	Instructive	Active direct	Level 2 - Developing
Gatsha	Instructive	Active direct	Level 2 - Developing

Table 9.3 provides the alignment and nonalignment between novice physical sciences teachers' beliefs and goals adjacent to their IBI practices. The noticeable pattern emerging from these findings was a direct relationship between novice physical sciences teachers' beliefs and goals to their IBI practices. Amalia and Gatsha had the same beliefs, goals, and classroom practices. They expressed the same instructive beliefs that are teacher-centred but focus on providing experience to learners through hands-on activities. They adopted an active direct goal that influenced their actions to provide hands-on experiences to learners. Their IBI was level two, developing inquiry, characterised by teacher-centred activities but with some active engagement of learners.

Nelisa's pattern also revealed a direct relationship, the same as in the case of Amalia and Gatsha but on different levels. She expressed learner-centred responsive beliefs that focused on learner-teacher collaboration and knowledge development. She had a learner-focused, guided inquiry goal that promotes creating a community of learners whose members share responsibility for understanding the physical world, particularly with respect to using science tools. Her level three, proficient inquiry classroom practices were learner-centred and focused on active learners' engagement and knowledge construction. Nelisa, Amalia, and Gatsha's teaching and learning beliefs aligned with their overarching goals. This finding is similar to Kang (2008), who studied the beliefs and goals of pre-service teachers. The study findings showed that pre-service teachers' personal beliefs and teaching goals were congruent. For example, teachers with naive epistemological beliefs (i.e., traditional) were likely to deliver information as a primary instructional goal (didactic). Pre-service teachers with sophisticated epistemologies espoused teaching goals consistent with the current science education reform.

Contrarily, Wayde did not have a pattern that showed a direct relationship between beliefs and goals to classroom practices and expressed traditional beliefs that focused on knowledge transmission and structure. He adopted an active direct goal, an overarching goal of providing hands-on experiences to learners. However, his IBI practices were on level one, teacher-centred pre-inquiry with no inquiry attempt. The alignment was between teaching and learning beliefs with IBI practices and nonalignment between an overarching goal with IBI practices. This finding is similar to Bol and Strage's (1996) and Sizer et al.'s (2021) results that teachers' practices are at odds with their expressed goals.

The findings in Table 9.3 are not surprising, considering the literature on the relationship between beliefs and classroom practices. Even though the findings in this study revealed a consistent relationship between teaching and learning beliefs to IBI practices for all four novice teachers, the literature still reveals the mismatched relationship between beliefs and classroom practices. According to Bryan (2012), the relationship between teachers' beliefs and classroom practices has two conflicting perspectives, congruent (i.e., consistency) and incongruent (i.e., inconsistency). For example, in their studies, Mansour (2013) and Ozel and Luft (2013) reported a consistent relationship between beliefs and classroom practices. At the same time, Capps et al. (2016) and Lebak (2015) reported an inconsistency between beliefs and classroom practices. Concerning goals, the findings revealed a mismatch, consistent and inconsistent relationship between novice teachers' goals and IBI practices. The relationship between Nelisa, Amalia, and Gatsha was consistent and inconsistent for Wayde.

9.4 The influence of teacher beliefs and goals on IBI practices

The third sub-question was:
Why do novice physical sciences teachers' beliefs and goals relate to their IBI practices in the manner that they do?
This question provided valuable information to understand better what influences the relationship observed in Table 9.3 between novice physical sciences teachers' beliefs and goals about IBI practices. I synthesised the results from questions one and two analysis to understand why novice physical sciences teachers' beliefs and goals relate to their IBI practices. To understand why teachers act in a particular manner, one must examine their goals and the ways these goals are articulated within work contexts and the tasks within those contexts. Recently, Hutner and Markman (2017) proposed a goal-driven teacher cognition model that describes the relationship between goal, mediating, and environmental representations. As a result, I focused on the novice teachers' beliefs and goals to understand the relationship with IBI practices.

All four novice teachers had content-driven specific goals (to develop learners' knowledge of terms, facts, concepts, and theories) and skills-driven specific goals (i.e., to develop learners' laboratory skills) (see Figures 5.1, 6.1, 7.1, and 8.1.). However, novice teachers differ in their overarching goals. For example, Nelisa adopted an overarching goal of using guided inquiry. During lessons one and two, Nelisa pursued the content and skills-driven specific goals of developing learners' skills in using laboratory materials and learning the concepts used during the acid-base titration process. These specific goals were tied to the actions and activities during classroom practices. Then these specific goals together supported the intermediate of developing physical sciences knowledge and skills. The intermediate goals reinforce the overarching goals of teaching using guided inquiry. While Nelisa explained her actions and activities with these specific goals, the level of practice was rated as proficient inquiry with a guided inquiry goal. Therefore, Nelisa had content and skills-driven specific goals with learner-oriented activities (refer to figure 5.1 for Nelisa's goal structure).

Furthermore, Amalia and Gatsha had an active direct as their overarching goal. Amalia justified her actions during the lesson by saying that she wanted her learners to learn the concepts and theories of electric circuits. She also wanted learners to develop observation and measurement skills during the PhET simulation. These were Amalia's content and skills-driven specific goals that justified her actions and activities during classroom practices. These specific goals supported her intermediate goal of developing physical sciences knowledge and skill, which supported the active direct goal, the same as Gatsha, who also had the specific goals for learners to understand the concepts of kinetic and gravitational energy laws and be able to apply them when doing calculations during lessons two and three. These content-driven specific goals supported the intermediate goal of developing physical sciences knowledge and skills, which supported the active direct goal. While Amalia and Gatsha explained their actions and activities with these specific goals, the level of practice during classroom practices was rated as developing inquiry with an active direct goal. Therefore, Amalia and Gatsha had content and skills-driven specific goals with teacher-oriented activities (refer to figures 7.1 and 8.1 for Amalia and Gatsha's goal structures).

Nelisa, Amalia, and Gatsha had the same content and skills-driven specific goals during classroom practices that justified their actions and activities during classroom practices. However, their actions and activities tied to the same specific goals differed. For example, the goal to develop learners' physical sciences knowledge and skills led to Nelisa engaging learners initially with an exploration, focusing on their involvement in knowledge construction and then explaining. This was Nelisa's lessons one and two, where learners conducted acid-base titration experiments. During the lessons, she was a facilitator, and many more characteristics qualified her for a proficient inquiry rating. Nelisa had content and skills-driven goals but wanted her learners to gain a deep understanding of physical sciences concepts using activities such as experiments and laboratory work. Nelisa had learner-oriented activities.

In Amalia's lesson, learners did series and parallel connection experiments using PhET simulation. She spent more time explaining the physical concepts and engaging learners with hands-on activities after explanations. Amalia's classroom actions qualified her for developing inquiry. Like Amalia, Gatsha explained and demonstrated kinetic and gravitational potential energy concepts. His actions during classroom practices qualified him for developing inquiry. The same specific goals justified the same intermediate goal of developing physical sciences knowledge and skills. Amalia and Gatsha also had content and skills-driven goals that wanted their learners to better understand physical sciences content. They used traditional instructional approaches combined with PhET simulations and demonstrations. Amalia and Gatsha had teacher-oriented activities.

The above finding of the relationship between novice teachers' goal systems and classroom practices is unusual. However, it is significant in this study because it provides empirical evidence that explains how goals influence science teachers' classroom actions. Firstly, it supports the claim that overarching goals are the ones that manifest during classroom practices. Even though the teacher can tie the specific goals to actions the goals in the long-term memory, overarching goals drive the classroom actions. Nelisa, Amalia, and Gatsha had the same content and skills-driven specific goals but adopted different overarching goals, which resulted in different classroom actions. From this interpretation, there was consistency between Nelisa, Amalia, and Gatsha's overarching goals and IBI practices. Similar to Gonzalez-Howard and McNeill (2019), who found that two teachers implementing the same argumentation lesson exhibited slightly different instructional practices as a result of different primary goals. Also, Hutner and Markman (2017) and Höchli et al. (2018) agree that overarching goals are the ones that drive teachers' actions during classroom practices.

Secondly, the findings support the assumption that teacher cognition is goal-driven and that teachers' overarching goals drive their instructional practices. Put another way, teachers act in ways that lead to the satisfaction of one or more of the goals they hold during classroom practices. Nelisa's overarching goal of guided inquiry was the one that drove her proficient classroom practices. Similarly, Amalia and Gatsha's active direct goal drove their developing inquiry classroom practices. These goals were active during classroom practices. In their studies, Hutner (2015) and Rojas-Perilla (2018) attest to the assumption that active goals in teacher cognition drive the pre-service teachers' classroom actions. Again, these findings suggest that exploring novice teachers' goals that they pursue provides an additional lens to understand their teaching practices better.

However, Wayde's results demonstrated a different and unfamiliar case. As explained above, Wayde verbalised the adoption of an active direct goal. His overarching active direct goal did not manifest during classroom practices, but his traditional beliefs aligned with his classroom actions. He believed in knowledge transmission as the all-knowing sage, drilling content for learners' understanding, and his lessons were teacher-centred during classroom practices. Wayde had teacher-oriented activities. He did not attempt any inquiry practices and was rated at pre-inquiry practices. Wayde's content and skills-driven specific goals for lesson one were for learners to understand the topic and to be able to explain how diffraction and waves work. For lessons two and three, he wanted learners to use specific laboratory methods to calculate the amount of certain chemicals they may need for experiments. Then these content and skills-driven specific goals together supported the intermediate goal of developing physical sciences knowledge and skills, which was supposed to activate the overarching goal of active direct. Even though he adopted an active direct goal, his teacher-oriented activities in pre-inquiry manifested the goal of knowledge transmission. In other words, the goal active in cognition, driving Wayde's classroom actions, was a 'didactic direct' goal.

There are two possible explanations for Wayde's case. Firstly, is the consideration that teachers hold multiple goals in their long-term memory, and only active goals will drive classroom practices (Hutner & Markman, 2017). Wayde's findings of goal-practices nonalignment suggested that the 'active direct' goal was not activated to drive his classroom practices. However, his traditional teaching and learning beliefs were able to activate the related didactic direct goal. Active mediating representation, i.e., beliefs in this study, are able to activate related goal representation. Beliefs mediate and provide information regarding which goal is worthy of being pursued and classroom actions that lead to the satisfaction of that goal (Hutner & Markman, 2017). In Wayde's case, the traditional, teacher-centred beliefs activated the didactic direct goal (i.e., the goal for knowledge transmission) and the classroom practices related to the didactic direct goal. Aguirre and Speer (2000) argue that beliefs play a central role in a teacher's selection and prioritization of goals and actions. Moreover, Friedrichsen

(2002) also found teacher orientations (i.e., considered overarching goals in this study) to be strongly influenced by teacher beliefs.

Secondly, Wayde held traditional beliefs and adopted an active direct goal with pre-inquiry instruction. There was nonalignment between Wayde's teaching and learning beliefs aligned with classroom practices. When a teacher's classroom practices are not aligned with IBI practices, one reason may be that the mediating and environmental representations currently active do not support the activation of the goal. Wayde's traditional beliefs and traditionally arranged classroom did not support the activation of active direct but the didactic direct goal. Wayde's case might provide evidence for the claim that goal representations are distinct from mediating representations, i.e., beliefs in this study. If goals were the same as beliefs, one would assume Wayde to hold traditional beliefs with a didactic direct goal aligned with those beliefs. This finding supports Hutner and Markman's (2017) claim of defining beliefs based on their role in teacher cognition. According to them, mediating representations, i.e., beliefs, mediate the processes of choosing among goals stored in long-term memory. Also, Aguirre and Speer (2000) support that beliefs influence the construction of their goals in response to those interactions. Beliefs active during planning and teaching tend to be those that aid in and lead to the successful achievement of the currently active goal.

Wayde believed that learners learn physical sciences concepts through knowledge transmission. He maximised learning by providing content to learners who should listen to him and apply what they have learned during the assessment task. When one of the learners incorrectly solved the problem on the board during teaching and learning, he interfered with the learner's presentation. He started explaining how to calculate the number of moles in the given problem. His focus was on the correctness of the answer. These beliefs were active during teaching and learning and activated an overarching didactic direct goal. Similar to Nelisa, Amalia, and Gatsha's case, their teaching and learning beliefs aligned with their goals, indicating that their beliefs influenced the adoption of their overarching goals. For example, Nelisa believed her role was to be a facilitator and maximise learning through learners' knowledge construction and collaboration. These teaching and learning beliefs were active in cognition and activated an overarching goal to teach through guided inquiry.

In literature, the nonalignment of teachers' beliefs and practices is often attributed to ecological factors, such as time constraints, assessment-based educational systems, students' abilities, and attitudes. According to Hutner and Markman (2017), environmental representations correspond to the current status of a teacher's environmental context. In other words, the goals teachers pursue are influenced by their teaching and learning beliefs and environmental factors. When active in teacher cognition, the environmental factors provide affordances or constraints to the goals that teachers adopt. For these novice teachers, social and physical factors influenced their goal adoption. Amalia, for instance, relied more on the guidance from the district SES and the book provided by them with previous question papers. As a result, she focused more on teaching and drilling learners to answer the questions during assessment tasks. Even though her learners engaged in practical work, it was more for explanation than exploring. The environmental factor of high-stakes examinations constrained Amalia and influenced her actions in adopting teacher-focused goals. The high-stake examination factor and the instructive teaching and learning beliefs mediated the adoption of the teacher-focused goal, active direct goal. Hutner and Markman (2017) attested that context influences people's actions to satisfy their goals. However, before specific goals define what to do and how to do it, they consider the environmental representation, i.e., affordances and constraints which specify how goals one step up in the hierarchy can be achieved (Höchli et al., 2018; Hutner & Markman, 2017).

As for Nelisa and Amalia, the environmental factors mediate the adoption of guided and active-direct goals, respectively. For instance, Nelisa's physical sciences lessons were taught and learned in the laboratory. The use of laboratory and responsive beliefs on maximising and occurring learning mediated the adoption of the guided inquiry goal. For Nelisa, the mediating and environmental representations active during planning and teaching tend to be those that aid in and lead to the successful achievement of guided inquiry goals. Amalia had a choice to use the laboratory when conducting PhET simulations. The environmental factor, i.e., the availability of a laboratory, facilitated the adoption of the active direct goal of engaging learners in hands-on experiences.

Furthermore, Nelisa did not struggle with disciplinary issues with her learners. She had developed a friendly teaching and learning environment. She was able to control learners' behaviour which then allowed learners to work independently. It was easy for Nelisa's learners to participate and engage during the lessons. As a result, Nelisa's learners had a positive attitude and were motivated to learn the physical sciences. The approachable learning environment factor provided affordances for Nelisa to adopt learner-focused goals. This is in line with literature revealing that context can influence the goal adoption of a science teacher (Anderson, 2012; Hutner & Markman, 2017).

This chapter explored the relationship between novice physical sciences teachers' beliefs and goals to IBI classroom practices. The findings revealed that novice physical sciences teachers expressed varied teaching and learning beliefs and goals about IBI, from teacher-centred to learner-centred. Their beliefs and goals aligned with their IBI practices. These findings suggest that novice physical sciences teachers' IBI practices lead to the satisfaction of the goals that they pursue during classroom practices. The goals that novice physical sciences teachers pursue are influenced by their teaching and learning beliefs and school environmental factors.

The next chapter discusses the findings from this study, which suggest that to better understand teachers' practices, it is important to consider not only their beliefs but also the goals they are pursuing. Implications from this study to help novice teachers develop learner-oriented goal reflective practices are also discussed. The chapter describes the limitations of the study and provides suggestions for future researchers regarding teachers' beliefs and goals for constructivist science teaching and learning.

CHAPTER TEN
CONCLUSION AND RECOMMENDATIONS

10.1 Introduction

Based on the rationale that IBI is an effective practice that may improve science education quality and the problem of the continued reliance on traditional, teacher-centred approaches by novice teachers, I embarked on conducting this study. I indicated in chapter one that science researchers on science teachers have struggled to understand the continued reliance on traditional instruction in science classes (Crawford, 2007; Fletcher & Luft, 2011; Hutner & Markman, 2017; Mokiwa, 2014; Nhase et al., 202; Ramnarain & Hlatswayo, 2018). Those conducting research focused on the relationship between science teachers' classroom practices and beliefs (Lebak, 2015; Luft, 2009; Luft et al., 2011; Ozel & Luft, 2013; Ramnarain & Hlatswayo, 2018; Wong et al., 2015). However, their studies have produced mixed findings that revealed (in)consistencies between science teachers' beliefs and classroom practices. These studies account for belief-practice inconsistency between science teachers' beliefs and classroom practices arising due to environmental factors. I became interested in this study to understand the thinking, i.e., mental constructs, beliefs, and goals, of novice physical sciences teachers and their IBI classroom practices. The broad purpose was to understand why novice physical sciences teachers teach the way they do and continue to use traditional practices rather than IBI in their classrooms. This study provides evidence that it is certainly possible that classroom practices are the result of overarching goals pursued by novice physical sciences teachers. The lack of IBI-related goals adoption by physical sciences teachers may contribute to the lack of IBI and promote traditional classroom practices. However, it is not only the overarching goal that influences practices since science teachers' teaching and learning beliefs and environmental factors mediate the goal adoption.

This study sought to answer the question: *What is the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices?* In pursuit of addressing the main question, the study addressed three critical sub-questions:

1. What beliefs and goals do novice physical sciences teachers hold about IBI?
2. How do novice physical sciences teachers' beliefs and goals relate to their IBI practices?

3. Why do novice physical sciences teachers' beliefs and goals relate to their IBI practices in the manner that they do?

This final chapter presents the overall conclusions of the findings related to the discussion with interpretations in the previous chapter nine in the context of the theoretical framework outlined in chapter three and recommendations from the research. Firstly, I discuss my findings within the terms of my research questions. Next, I discuss the implications of the study for lecturers, professional development leaders (i.e., SES), and science education researchers related to the development of novice physical sciences teachers' IBI practices. Finally, I comment on the limitations of my study and make recommendations for possible future directions for research in this field.

10.2 Summary of the findings

This study explored the relationship between novice physical sciences teachers' beliefs and goals to IBI classroom practice. I conceived this study with a limited understanding of the complexities of factors influencing novice physical sciences teachers' IBI classroom practices. And more specifically, the relationship between beliefs and goals and how they influence novice physical sciences teachers' IBI practices. Through the literature review, I found that there is limited existing research on novice physical sciences teachers' IBI practices. The literature review also corroborated the limited studies on the role of physical sciences teachers' beliefs and goals in developing IBI practices. Therefore, it was this study's significance to make this important contribution to science education research in the area of teacher cognition through this exploration. This section summarises the findings, including how my thesis responds to the research questions. I categorise the summary of the findings according to the sub-research questions.

10.2.1 Research question One: What beliefs and goals do novice physical sciences teachers hold about IBI?

In response to research question one, I found that novice physical sciences teachers held teacher-centred beliefs and goals to their IBI practices. Although they held teacher-centred beliefs, their levels were diverse and varied from traditional to instructive beliefs. I found the same trend with goals, where three novice teachers who held teacher-centred beliefs adopted teacher-centred active direct goals. One novice teacher who adopted learner-centred teaching and learning beliefs also adopted a learner-centred, guided inquiry goal. The study findings support the notion that novice physical sciences teachers have two sets of beliefs and goals, i.e., teacher and learner-centred (Fletcher & Luft, 2012; Kang, 2008). Interestingly, these novice physical sciences teachers had unique beliefs and goal systems even though they had undergone the same science curriculum. One would assume they still held teaching and learning beliefs formed during method courses from the teacher education programme. As suggested by Hutner and Markman (2017), there is a possibility that some of these novice physical sciences teachers developed beliefs during teacher education that have little influence on what they will actually do in their future classrooms.

Moreover, the findings of this study support the literature on the influence of environmental factors on teacher beliefs and goals. These factors included the physical structure of the school (i.e., does not have a laboratory), the layout of the classroom or laboratory, curriculum material from DBE (i.e., CAPS; Examination guidelines, annual teaching plan, prescribed text-books), lack of resources, the influence of SES in the teaching of physical sciences, time constraints, and the influence of the policy with the high-stake examination. Even though my study did not explore environmental factors in detail, they emerged during the discussion to influence teaching and learning beliefs and goal adoption. For example, one novice teacher had no laboratory or resources to engage learners in practical work and had to take learners to the nearest resource centre for practical work. All novice teachers mentioned the influence of SES and how they encourage using examination guidelines and prescribed DBE textbooks. This is not surprising since the literature cites the same physical and contextual factors influencing teaching and learning beliefs.

10.2.2 Research question Two: How do novice physical sciences teachers' beliefs and goals relate to their IBI practices?

I found the IBI of the three novice teachers to be teacher-centred. One novice teacher's IBI practices could be exclusively learner-centred at the proficient inquiry. The EQUIP ratings from pre-inquiry to developing inquiry reflected that novice physical sciences teachers were challenged with IBI enactment. Their concerns about covering physical sciences content and the need to ensure that their learners are examination-ready resulted in using direct instruction more frequently. Direct instruction was seen as an efficient method to impart large amounts of information to learners in a timely manner. Having three teachers from my sample teaching at pre and developing inquiry may suggest that the majority of novice physical sciences teachers generally teach at lower levels. This means that the instructional practices of novice teachers are generally more didactic than inquiry. The findings of this study also justify, to a large extent, the concerns discussed in chapter one that have been expressed by science curriculum officers and science educators about the low level of teachers' IBI practices. The level of IBI practices justifies even further the reason for concern.

In answering how beliefs and goals relate to IBI practices, this study's findings revealed a direct relationship between novice physical sciences teachers' beliefs and goals to IBI practices. Three novice teachers had teaching and learning beliefs and goals aligned with their IBI. Two novice physical sciences teachers held instructive beliefs and adopted active direct goals aligned to developing IBI. One novice teacher had responsive beliefs and adopted a guided inquiry goal aligned to proficiency IBI. These findings provide evidence that confirms that teachers' pursuit of goals guides classroom practices.

One finding from this study that may differ from other studies is that all four novice teachers held beliefs aligned with their classroom practices. When comparing the novice teachers' beliefs and goals discussed in section 10.3.1 above and their IBI practices, one can explain how they relate. Table 2.4 in chapter two suggested the alignment of teachers' beliefs and goals as explained in the literature. There is still a mismatch between novice sciences teacher beliefs and their classroom practices in science education. In some cases, novice physical sciences teachers express constructivist beliefs yet do not implement practices congruent to those beliefs.

I have mentioned above that the four novice teachers in this study were qualified physical sciences teachers, and three were studying towards their BEd Honours degree. Their teacher education equipped them with the knowledge and skills to be effective physical sciences teachers. Their physical sciences method modules emphasised teaching through IBI, which also is in the CAPS. One of the arguments that can be raised from these findings is the effectiveness of teacher education programs in preparing teachers to use IBI. Furthermore, these findings support Kang et al.'s (2013) suggestion that providing pre-service teachers with one method course focused on inquiry and IBI is not enough for the actual transfer between the methods course and practices. There is a need for continuous in-service teacher support programs for IBI.

10.2.3 Research question Three: Why do novice physical sciences teachers' beliefs and goals relate to their IBI practices in the manner that they do?

The novice physical sciences teachers in my study justified their classroom actions, i.e., practices, through the desired outcomes of their lesson. For example, when asked why they 'act' in that way during the SRI, they would say, 'I wanted my learners to be able to….'. These were the desired outcomes they had when planning their lessons and what was actually going on in their classroom. The desired outcomes of their lessons were their content and skills-driven specific goals they pursued during classroom practice. There was an alignment between their goal system (i.e., in the hierarchy) and what actually happened in their classrooms. This alignment indicates that what novice physical sciences teachers practiced was guided by their goal pursuit. The alignment provides evidence in this study that novice physical sciences teachers' classroom practices were driven by goal pursuit. The novice physical sciences teachers' goals presented in chapter nine revealed that the overarching goals that they adopted and pursued during classroom practices influenced their IBI practices.

Though the novice physical sciences teachers' overarching goals drove classroom practice, teaching and learning beliefs influenced their goals adoption. For example, in this study, Amalia and Nelisa had the same environmental factors but different teaching and learning beliefs. Their teaching and learning beliefs mediated the adoption of different overarching goals (see Table 9.3 in chapter nine). They expressed teaching and learning beliefs that were reflected in their overarching goals. This scenario was the same for Gatsha, and Wayde operationalised his beliefs into the overarching goal. The above findings provide evidence supporting Hutner and Markman's (2017) model that frames this study. According to the model, holding teacher-centred or learner-centred beliefs is important but not sufficient to drive IBI practices. Teachers' beliefs, whether teacher or learner-centred, mediate between the environmental factors for the adoption of the teacher or learner-focused goals. From a theoretical perspective of goal-driven cognition, the study findings imply that novice sciences teachers need to develop beliefs and knowledge reflective of IBI and goals to use such practices in their future classrooms. This study concludes that the science teachers' goal systems play an important role in their classroom practices. It provides evidence that novice teachers' goal systems may contribute to the implementation or non-implementation of IBI.

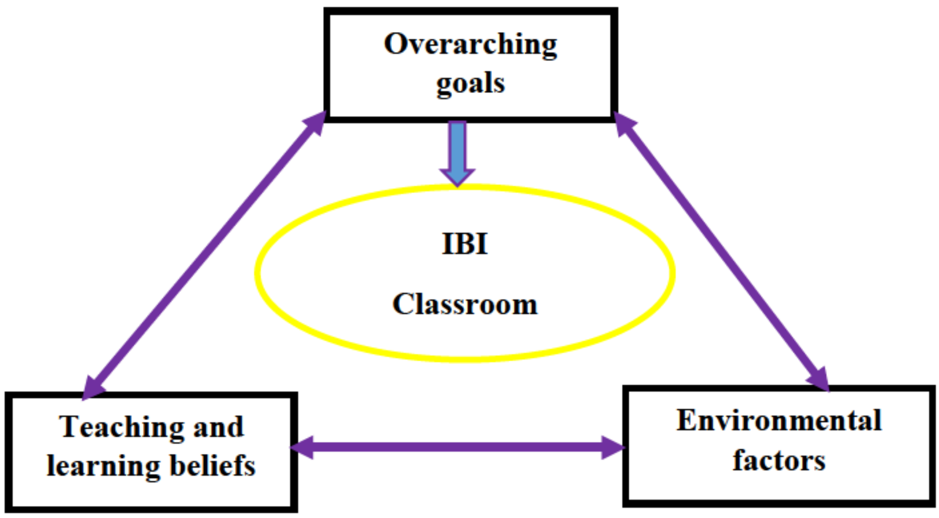
To answer the main research question: *What is the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices?*

Thus, answering the above question of the relationship between novice physical sciences teachers' beliefs and goals to IBI practices is more complex. To better understand this relationship, one needs to consider the goals that novice physical sciences teachers adopt and pursue, their active teaching and learning beliefs, and the context during classroom practices. This thesis considers overarching goals as the fundamental drivers of IBI practices. Nespor (1985), in his TBS, suggested that if the ultimate purpose of the research is to improve the practices of teachers, then the reasons that teachers have for acting as they do must be explored (i.e., their desired outcome). Nespor proposed the importance of establishing these reasons before even assessing the impact or success of IBI.

Using the findings from the analysis of the above three questions, I better understand how the teaching and learning beliefs and goals that novice physical sciences teachers hold influence their IBI practices in their different environmental settings. Figure 10.1 illustrates the interplay that may guide understanding of the relationship between novice physical sciences teachers' beliefs and goals to their IBI practices.

Figure 10.1

The relationship between teaching and learning beliefs, environmental factors, and goals to IBI



Teaching and learning beliefs and environmental factors are at the bottom of the diagram as they mediate for goal adoption. They are at the same level. The overarching goals are on top of the diagram, indicating the difference in the interplay of these mental constructs. The overarching goals are the main drivers of novice physical sciences teachers' IBI classroom practices. IBI is central in the diagram as the core practice in improving science education and developing 21st-century skills. The arrows indicate how each factor is influenced or interacts with others. This demonstrates the complex relationship between teachers' beliefs, environmental factors, and goals. Teaching and learning beliefs and environmental factors mediate the extent to which novice physical sciences teachers can implement IBI congruent with their active goals.

The model for science teacher cognition here extends Hutner and Markman's (2017) model of goal-driven teacher cognition. The model posits that novice physical sciences teachers' inquiry-based practices were goal-driven. However, science teachers' goals must be studied as a system within the hierarchy to explain the relationship between teacher cognition and IBI. In this study, novice physical science teachers pursued similar specific and intermediate goals, adopting different overarching goals. If I had studied their goals in isolation and compared them to their IBI, I would have concluded that they pursue goals that are not directly related to their IBI. Hence, I emphasise the inclusion of overarching goals in the model.

Unlike previous research studies, this study provides insights into the relationship between teaching and learning beliefs and goals and their connection to IBI practices. It highlights how teachers' beliefs influence the adoption of goals mediated by environmental factors. Additionally, this study has established that if novice physical sciences teachers need to use IBI in their teaching, they need to integrate this approach into the goal representations. This is one of the main differences between previous models of teacher cognition and the goal-driven model of cognition used in this study. The previous models assume that teaching and learning beliefs will have an influence on teachers' IBI practices.

10.3 Contribution of the study

The findings from my study do reflect some findings from past science research. However, there are some new insights into teaching and learning beliefs and goals related to novice physical sciences teachers. This study significantly contributes to the sciences literature regarding teachers' beliefs and goals. Firstly, this thesis provided evidence that novice physical sciences teachers' goal systems play an important role in their classroom practices. The findings of this study imply some possible explanations for why teachers teach the way they do, particularly in the case of teachers with beliefs and goals. Even though many studies still prioritise beliefs and PCK as drivers of teacher cognition, this thesis advocates that cognition is goal-driven.

The study also contributes to the alternative explanation of the relationship between teachers' beliefs and classroom practices. The literature still provides inadequate explanations when teachers exhibit beliefs that are not reflected in their teaching, i.e., inconsistency between beliefs and practices. The relationship between beliefs and practices is complex and not conclusive. (Bryan, 2012). However, the findings in this study are significant in that they show the importance of novice physical sciences teachers' goals and beliefs in influencing their IBI practices. This study's findings revealed that IBI practices do not occur when novice sciences teachers do not have the overarching goal and necessary beliefs to implement this form of instruction. For the above reasons, this study is important to the science education community because goals (i.e., science teaching orientations) play an important role in teacher IBI practices (Crawford, 2007; Friedrichsen, 2002). There is scant research associated with teachers' goals and particularly for novice science teachers.

This study adds to the research by allowing a new approach to exploring sciences teachers' overarching goals. I used vignettes (i.e., POSTT) to determine the overarching goals for novice teachers. Researchers have used the same to determine sciences teacher orientations, i.e., knowledge and beliefs (Guven et al., 2019; Ladachart, 2019; Nhlengethwa et al., 2020; Nyirenda, 2019; Ramnarain & Schuster, 2014; Sizer et al., 2021; Ward, 2016). However, additional research is needed to explore sciences teachers' goals using POSTT. The advantage of using vignettes such as POSTT in this study was its strength and ability to have sciences teachers reflect upon their thoughts and actions when responding to questions. As novice teachers read the cases with teaching scenarios, they visualised themselves teaching the same topics and how they would teach that in the classroom. There was a substantial degree of congruence between the visions for their classroom when planning and the actual goings-on of their classes.

10.4 Implications and Recommendations

The findings of this study have several implications for pre and in-service physical sciences teachers' professional development.

For teacher preparation programmes: The findings from this study provide supporting evidence for the goal-driven model of cognition proposed by Hutner and Markman (2017). Therefore, these findings may help improve the preparation of pre-service physical sciences teachers. I suggest efforts to develop goal reflective practices for novice teachers to improve their IBI practices. Focusing on novice physical sciences teachers' knowledge and beliefs to understand their practices is good but not enough. Kind (2016) suggested that having more knowledge about orientations (which I considered overarching goals in this study) can help to improve the understanding of how high-quality sciences teachers can be developed. The physical sciences method courses must develop novice physical sciences teachers' goal reflective practices. As Kang (2008) suggested, identifying teaching goals provides a clearer understanding of teachers' actions in the classroom.

Goal setting is a highly regarded subject and a widely embraced practice in the corporate world, but its presence in education on teaching is weaker. Camp (2017) emphasised the importance of goal setting and indicated that it has the potential to benefit teachers by providing a lens through which to scrutinize their teaching and the opportunity to chart their path toward learning and improvement. Many programs in our sciences courses emphasise the development of teachers' knowledge and beliefs and focus less on instructional goal setting. Goal setting can foster growth in teaching and also support learning. Setting goals, revisiting and modifying the goals based on actual teaching experiences could provide the teachers with an avenue to support themselves in the absence of inquiry-based induction coaching or external professional development.

It is important for physical sciences teachers to be given an opportunity to review their beliefs. Some teachers with learner-centred beliefs are unaware that their beliefs have shifted or changed to teacher-centred. As a result, pre-service sciences teachers can be given opportunities to identify their beliefs to see whether they can keep pace with constructivist teaching, i.e., IBI. In-service sciences teachers must also have professional development opportunities that allow them to examine their beliefs. It is impossible to change their beliefs regarding constructivist practices without knowing what in-service science teachers believe. Professional development activities that have a superior effect on teachers' beliefs (Luft & Roehrig, 2007) would be helpful in eliciting and changing the science teaching beliefs of novice and experienced teachers. Richardson (1996) noted the significant impact in-service teacher professional development had on the modification of beliefs.

Another suggestion for physical sciences teachers is to learn how to use curriculum resources in ways that engage learners in the learning process. The Department of Education plays a more prominent role in the classrooms for novice sciences teachers. They provide physical sciences teachers with documents and books that promote teaching for examination. For example, Nelisa and Gatsha were both teaching grade 12 and using curriculum material like CAPS, annual teaching plan, and examination guidelines. However, their IBI practices were at different levels, developing inquiry for Gatsha and proficiency inquiry for Nelisa. As grade 12 teachers, they were under the same pressure from SES to increase the pass rate in physical sciences. However, Nelisa was able to use curriculum materials to encourage learners' engagement in science practices. Other research has shown the curricular materials that districts adopt, such as textbooks, are also incompatible with reform-oriented science teaching. The implication is that novice sciences teachers need to be prepared to deal with teaching constraints that inhibit constructivist teaching approaches, pressure from SES, resources, and standardised examinations.

Education sub-structures: Local school districts also bear a responsibility to ensure that their teachers are highly trained and able to utilise a variety of instructional practices, including inquiry. Supportive, ongoing professional development in inquiry methods is crucial to successfully implementing unfamiliar strategies. SES need to provide sciences teachers with professional development opportunities and develop induction programmes that support the continuing development of emerging teaching practices. Moreover, professional development should support the development of learner-centred instruction and implementation, teacher beliefs, and goal reflective practices since this study provided evidence that the teachers' goal systems may contribute to the lack of IBI practices in science classes. Luft and Roehrig (2007) encouraged the need for sciences teachers to have professional development because, without adequate learner-centred support, they could also revert to traditional teacher-centred ideologies.

Physical sciences novice teachers are not free to do their job. Teaching physical sciences has come with explicit and implicit ‘instructions’ on how it must be done from educational substructures. SES do not consider what physical sciences teachers do during classroom practices appropriate to what they think. This will shed light on SES, who have obligations for professional development, not to limit novice physical sciences teachers’ ability to make desired changes to their teaching. Furthermore, comprehensive support systems, such as university-district partnerships and learning professional communities, should be encouraged to support the development of novice sciences teacher practices.

For Research*:* This study is important to the science education community because science teaching goals play an important role in teacher practices. There is scant research associated with teachers’ goals and their influence on classroom practices. To help fill this gap, I explored the relationship between novice teachers’ beliefs and goals to IBI. There is a need for additional research on teachers’ goals to gain insight into teachers’ thinking and a full understanding of the relationship between the goal systems of science teachers and their classroom practices. I mentioned in chapter three that the goal-driven teacher cognition model is new. Therefore, there is a need to conduct more research studies to explore different avenues that will explain teachers’ classroom actions and behaviour. Moreover, this study was conducted with a sample of four novice physical sciences teachers. A similar study can be done with a large number of experienced physical sciences teachers to explore the nature of the relationship between their beliefs and goals. Learning how goal-driven teacher cognition works with experienced physical sciences teachers would be stimulating.

At this point in their careers, novice physical sciences teachers are at the stage of developing their teacher identity. Science teacher identity influences the pedagogical practices and philosophies implemented in the science classroom. Moreover, teacher identity plays a role in the goals sciences teachers set and pursue for their learners. There is a need for a study to explore the relationship between teachers’ beliefs, goals, and identity. It will be interesting to understand how teacher identity influences teachers' beliefs and goals for their IBI.

10.5 Limitations

It is important to note that there were limitations to this study. One limitation of this study was the small sample size. Although the sciences teachers participating in the study were from a purposive sample of a slightly larger group of novice physical sciences teachers, the sample size was small. The sample also only represented novice physical sciences teachers from one teacher preparation program, a university. Therefore, the small sample size and the lack of representation of novice physical sciences teachers from other teacher preparation programs pose issues with the potential generalisability. However, to generalise was not the purpose of this study. So, working with four participants provided me with rich data around beliefs and goals, which is an aim of the qualitative approach.

Another limitation of this study was some form of partisan issues that may arise during data gathering. In chapter one, I mentioned that I was the ex-lecturer for some of the science content and science methods courses the four novice physical sciences teachers participated in during their pre-service education. I had an opportunity to be their university mentor during their student teaching practicums. To avoid bias, I used multiple and various data gathering tools and sources that helped to alleviate possible bias during data gathering and analysis.

10.6 Conclusion

In conclusion, ongoing research into physical sciences teacher cognition is critical for identifying and understanding how teachers perceive their science teaching beliefs and goals, and knowing what guides their instructional decisions becomes especially important. In the late stages of this research, the coronavirus (COVID-19) pandemic outbreak brought many changes across the education sector. Face-to-face teaching and learning were impossible, and there was a need for remote and online learning. This transformation required the development of online learning systems. The spread of COVID-19 taught us valuable lessons about designing teaching and learning activities and assessment tasks that encourage independence and responsibility towards one's own learning. Future research on teachers' beliefs and goals needs to consider the new environmental context of online physical sciences teaching and learning, including the impact of various factors.

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APPENDICES

APPENDIX 1A: ethical clearance

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

28 January 2019

Mrs Sebenzile Ngema 981226240
School of Education
Edgewood Campus

Dear Mrs Ngema

Protocol reference number: HSS/0063/019M
Project Title: Exploring physical sciences teachers' cognition about Inquiry-Based Instruction: A case study of novice teachers in Pinetown district.

Full Approval – Expedited Application

In response to your application received 17 January 2019, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]

Dr Shamila Naidoo (Deputy Chair)

/px

cc Supervisor: Dr A James and Dr D Sibana
cc. Academic Leader Research: Dr SB Khoza
cc. School Administrator: Ms S Jeenarain, Ms M Ngcobo, Mr SN Mthembu

Humanities & Social Sciences Research Ethics Committee
Dr Rosemary Sibanda (Chair)
Westville Campus, Govan Mbeki Building
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APPENDIX 1B: Gatekeepers letter

education

Department:
Education
PROVINCE OF KWAZULU-NATAL

Enquiries: Phindile Duma | Tel: 033 392 1063 | Ref.:2/4/8/1701

Mrs S Ngema
513 The Towers
2 Bamboo Lane
Pinetown
3610

Dear Mrs Ngema

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"AN EXPLORATION OF PHYSICAL SCIENCES TEACHERS' COGNITION ABOUT INQUIRY-BASED INSTRUCTION: A CASE STUDY OF NOVICE TEACHERS IN PINETOWN DISTRICT"**, in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the Intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 18 December 2018 to 01 May 2021.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Phindile Duma at the contact numbers below.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report/dissertation/thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

[redacted]

[redacted]
Dr. EV Nzama
Head of Department: Education
Date: 20 December 2018

..Championing Quality Education - Creating and Securing a Brighter Future

KWAZULU-NATAL DEPARTMENT OF EDUCATION
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APPENDIX 2A:

PEDAGOGY OF SCIENCE TEACHING TEST (POSTT)-PHYSICAL SCIENCES

Dear Research Participant

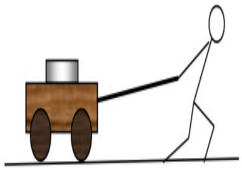
Thank you for agreeing to participate in this research study. Your responses to the questions below will be used to help the researcher better understand novice physical sciences teachers' beliefs and goals about inquiry-based instruction. All information collected will be kept **confidential** to the extent allowed by University policy. A code number will be assigned to each questionnaire so that responses will be completely anonymous during the analysis process. This portion of the research study is composed of classroom physical sciences teaching vignettes similar to teaching practices one can find in any physical sciences classroom today. **There are no right or wrong answers.** Instead, the researcher wants to know *what you think* is best to teach these particular Physical Sciences topics and why. As you read each vignette, think about how you might teach Physical Sciences in a similar situation. Respond accordingly.

Table 1:

Type of instruction	
Didactic Direct	The teacher presents the science concept or principle directly and explains it. The teacher illustrates with an example or demonstration. There are no learner activities, but the teacher takes learner questions and answers them or clarifies them.
Active Direct	Same as the direct exposition above initially, but this is followed by a learner activity based on the presented science, e.g., hands-on practical verification of a law.
Guided Inquiry	The teacher approaches topics by learners exploring a phenomenon or idea, guiding them toward the desired science concept or principle arising from the activity. The teacher may explain further and gives examples to consolidate. Questions are dealt with by discussion.
Open Inquiry	Minimally guided by the teacher, learners are free to explore a phenomenon or idea in any way they wish and devise ways of doing so. The teacher facilitates but does not prescribe. The process is generally considered the most important thing, and learners present what they found.

LESSON ON FORCE AND MOTION (PHYSICS)

Ms. Buthelezi is preparing a lesson to introduce her grade 11 learners to the relationship between force and motion, namely that a net force will cause an object to speed up or slow down (Newton's 2nd Law). The classroom has available a loaded wagon to which a pulling force can be applied. Ms. Buthelezi is considering four different approaches to the lesson.



(I) Identify the instructional type for each strategy that the teacher is using:

	Type of instruction
A. Write a clear statement of Newton's 2nd Law on the board and explain it carefully to my learners. Then I would demonstrate the Law by pulling on a loaded wagon with constant force in front of the class as they observed the motion.	
B. Raise the question of what kind of motion results from a constant force. I would then guide my learners to explore the question themselves by pulling on a loaded wagon and observing what happens. From the evidence, they would then propose a possible law.	
C. Write a clear statement of Newton's 2nd Law on the board and explain it carefully to my learners. I would then have the learners verify the Law by pulling on a loaded wagon themselves and confirming what type of motion results.	
D. Raise the question of whether there is any relationship between force and motion. My learners would then be free to explore this safely in the laboratory. Afterward, we would have a class discussion of their findings.	

(II) Thinking about how you would teach this lesson, which is the most similar to how you teach the lesson?

A	**B**	**C**	**D**

(III) Please explain why you choose this particular instructional strategy over the three options (i.e., why is it better than the other strategies)? Please include any clarifying information you think will help the researcher understand your response better.

MAGNETS AND MATERIALS (PHYSICS)

Ms. Gumede has introduced the topic of magnetism to her grade 10 learners, and they have learned that bar magnets attract certain kinds of materials that have iron in them. For today's new lesson, she has available bar magnets and a variety of food containers made of plastic, iron, aluminium, steel, and glass.

(I) Identify the instructional type for each strategy that the teacher is using

	Type of instruction
A. I would tell the learners that our assignment for the day is to solve the puzzle of which food containers contain iron and which do not. Learners would be asked to think of how they could find out, and they would either come up with or be prompted to use bar magnets to test the various kinds of food containers.	
B. I would remind the class that magnets attract materials that contain iron (including most steels) and then show them how the bar magnet attracted the containers made from steel or iron, but not any of the other containers.	
C. I would tell the class to recall that magnets attract materials containing iron (including most steels) and then have small groups of learners use bar magnets to sort the food containers into those containing iron and those that do not.	

D. Each group of learners would be provided with a bar magnet and various kinds of food containers. I would not outline a specific task but ask them to find out what they can about the collection and report back their observations and conclusions.	

(II) Thinking about how you would teach this lesson, which is the most similar to how you teach the lesson?

A	B	C	D

(III) Please explain why you choose this particular instructional strategy over the three options (i.e., why is it better than the other strategies)? Please include any clarifying information you think will help the researcher understand your response better.

TEMPERATURE AND SOLUBILITY (CHEMISTRY)

Mr. Clark's grade 11 learners have learned that sugar becomes more soluble in water as the water temperature increases. Now he wants his learners to learn that, unlike sugar, the solubility of salt does *not* increase with temperature. Graduated cylinders of hot and cold water, salt, sugar, and stir sticks are available.

(I) Identify the instructional type for each strategy that the teacher is using

	Type of instruction
A. I would explain that while we found that sugar is more soluble in hot water, not all solids behave the same way. I would demonstrate using salt instead of sugar in the graduated cylinders of hot and cold water.	

B. I would pose the question of whether all solids might dissolve better in hot water like sugar did. I would ask them to design and do an experiment to test whether salt dissolves better in hot or cold water.	
C. I would give my class sets of graduated cylinders, salt, sugar, and hot and cold water, and ask them if they could find out anything about salt versus sugar dissolving in water. I would not prescribe what they should do. Later, we would discuss what they did and what they found out.	
D. I would explain that while we found that sugar is more soluble in hot water, not all solids behave the same way. I would then have them verify this in the laboratory using the same amount of salt in each hot and cold water cylinder.	

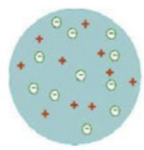
(II) Thinking about how you would teach this lesson, which is the most similar to how you teach the lesson?

A	B	C	D

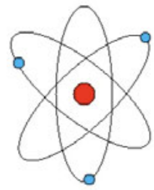
(III) Please explain why you choose this particular instructional strategy over the three options (i.e., why is it better than the other strategies)? Please include any clarifying information you think will help the researcher understand your response better.

WHAT IS AN ATOM LIKE? (CHEMISTRY)

Ms. Dlamini taught her grade 10 learners that matter is made of atoms. She then asked what an atom itself might be like. She wants to introduce the idea of *models* in science: though we cannot see atoms, we can envisage models to account for their properties. She said one clue about atoms was that scientists had discovered there are negative particles (electrons) in atoms, though atoms are neutral overall. She has available large posters of the older 'plum pudding' model and the subsequent 'nuclear atom' model.



"Plum pudding"



Nuclear Atom

(I) Identify the instructional type for each strategy that the teacher is using

	Type of instruction
A. Begin by asking the learners to suggest their own models for what an atom might be like, given that it has electrons but is neutral overall. I would then have them compare their ideas with the 'plum pudding' and 'nuclear atom' models. Drawing on their comments, I would explain how scientists arrived at the first model and why they later changed to the second model. Then I would then have the learners sketch different example atoms drawing information from a Periodic Table	
B. Display the posters of both models and explain how scientists arrived at the first model and why they later changed to the second model. Referring to information from the Periodic Table, I would show how the 'nuclear atom' model could represent the atoms of different elements.	
C. Display the posters of both models and explain how scientists arrived at the first model and why they later changed to the second model. I would then have the learners sketch different example atoms drawing information from a Periodic Table.	
D. Ask the learners to think of as many possible models as they can of how an atom might look. I would have them report on their ideas with sketches. Most of the lesson time would be given to learners proposing and supporting their models. I would end the lesson by having the learners compare and contrast their ideas with	

the ‘plum pudding’ and ‘nuclear atom’ models, noting that scientists now embraced the latter.	

(II) Thinking about how you would teach this lesson, which is the most similar to how you teach the lesson?

A	B	C	D

(III) Please explain why you choose this particular instructional strategy over the three options (i.e., why is it better than the other strategies)? Please include any clarifying information you think will help the researcher understand your response better.

THANK YOU FOR PARTICIPATING IN COMPLETING THIS QUESTIONNAIRE.

APPENDIX 2B:

MODIFIED TEACHING GOALS INVENTORY (TGI)

Dear Research Participant

Thank you for agreeing to participate in this research study. Your responses to the questions below will be used to help the researcher better understand novice physical sciences teachers' beliefs and goals about inquiry-based instruction. All information collected will be kept **confidential** to the extent allowed by University policy. A code number will be assigned to each questionnaire so that responses will be completely anonymous during the analysis process.

The Teaching Goals Inventory (TGI) is a self-assessment of instructional goals. Its purpose is twofold:

(1) To help physical sciences teachers become aware of what they want to accomplish in teaching;

(2) To provide a starting point for discussing instructional goals among physical sciences teachers.

The TGI has two parts, PART A and PART B. **There are no right or wrong answers.** Instead, the researcher wants to know *what you think* are your personal instructional goals in teaching physical sciences topics.

PART A

Please respond to each item on the inventory in relation to your physical sciences teaching. Rate the importance of each of the thirty-three goals listed below. Assess each goal's importance to what you deliberately aim to have your learners accomplish, rather than the goal's general worthiness or overall importance to your school's mission.

For each goal, circle only **one** response on the l-to-5 rating scale. You may want to read quickly through all thirty-three before rating their relative importance.

In relation to physical sciences teaching, indicate whether each goal you rate is:

5	Essential	a goal I always/nearly try to achieve
4	Very important	a goal I often try to achieve
3	Important	a goal I sometimes try to achieve
2	Unimportant	a goal I rarely try to achieve
1	Not applicable	a goal I never try to achieve

Rate the importance of each goal to what you aim to have learners accomplish in your Physical Sciences teaching.

		Essential	Very important	Important	Unimportant	Not applicable
		5	**4**	**3**	**2**	**1**
1	Develop the ability to apply principles and generalizations already learned to new problems and situations	**5**	**4**	**3**	**2**	**1**
2	Develop analytic skills	**5**	**4**	**3**	**2**	**1**
3	Develop problem-solving skills	**5**	**4**	**3**	**2**	**1**
4	Develop ability to draw reasonable inferences from observations	**5**	**4**	**3**	**2**	**1**
5	Develop ability to synthesize and integrate information and ideas	**5**	**4**	**3**	**2**	**1**

6	Develop the ability to think holistically: to see the whole as well as the parts	**5**	**4**	**3**	**2**	**1**
7	Develop ability to think creatively	**5**	**4**	**3**	**2**	**1**
8	Develop ability to distinguish between fact and opinion	**5**	**4**	**3**	**2**	**1**
9	Improve skill at paying attention	**5**	**4**	**3**	**2**	**1**
10	Develop ability to concentrate	**5**	**4**	**3**	**2**	**1**
11	Improve memory skills	**5**	**4**	**3**	**2**	**1**
12	Improve listening skills	**5**	**4**	**3**	**2**	**1**
13	Improve speaking skills	**5**	**4**	**3**	**2**	**1**
14	Improve reading skills	**5**	**4**	**3**	**2**	**1**
15	Improve writing skills	**5**	**4**	**3**	**2**	**1**
16	Develop appropriate study skills, strategies, and habits	**5**	**4**	**3**	**2**	**1**
17	Improve mathematical skills	**5**	**4**	**3**	**2**	**1**
18	Learn terms and facts of this subject	**5**	**4**	**3**	**2**	**1**
19	Learn concepts and theories in this subject	**5**	**4**	**3**	**2**	**1**
20	Develop skills in using materials, tools, and/or technology central to Physical Sciences	**5**	**4**	**3**	**2**	**1**
21	Learn to understand perspectives and values of this subject	**5**	**4**	**3**	**2**	**1**
22	Prepare for transfer or graduate study	**5**	**4**	**3**	**2**	**1**
23	Learn techniques and methods used to gain new knowledge in Physical Sciences	**5**	**4**	**3**	**2**	**1**
24	Learn to evaluate methods and materials in this subject	**5**	**4**	**3**	**2**	**1**
25	Learn to appreciate important contributions to this subject	**5**	**4**	**3**	**2**	**1**
26	Develop ability to work productively with others	**5**	**4**	**3**	**2**	**1**
27	Develop management skills	**5**	**4**	**3**	**2**	**1**
28	Develop leadership skills	**5**	**4**	**3**	**2**	**1**
29	Develop a commitment to accurate work	**5**	**4**	**3**	**2**	**1**
30	Improve ability to follow directions, instructions, and plans	**5**	**4**	**3**	**2**	**1**
31	Improve ability to organize and use time effectively	**5**	**4**	**3**	**2**	**1**
32	Develop a commitment to personal achievement	**5**	**4**	**3**	**2**	**1**
33	Develop ability to perform skilfully	**5**	**4**	**3**	**2**	**1**

In general, how do you see your primary role as a Physical Sciences teacher? Although more than one statement may apply, please choose only one statement and make a cross (X)	
Helping learners develop high order thinking skills	
Helping learners develop basic learning skills for academic success	
Teaching learners facts and principles of subject matter in Physical Sciences	
Preparing learners for future careers and jobs	

PART B

Read each question, think about your Physical Sciences teaching, then respond accordingly.

QUESTIONS:

1. What are your goals for teaching physical sciences (i.e., what do you expect your learners to be able to learn and do)?

2. What knowledge and skills do you think are important for your learners to develop in your classroom?

3. What expectations do you have for your learners when learning physical sciences?

THANK YOU FOR PARTICIPATING IN COMPLETING THIS QUESTIONNAIRE.

APPENDIX 2C:

MODIFIED TEACHERS' BELIEFS ABOUT IBI PRACTICES.

Dear Research Participant

Thank you for agreeing to participate in this research study. Your responses to the questions below will be used to help the researcher better understand novice Physical Sciences teachers' beliefs and goals about inquiry-based instruction. All information collected will be kept **confidential** to the extent allowed by University policy. A code number will be assigned to each questionnaire so that responses will be completely anonymous during the analysis process. **There are no right or wrong answers.** Instead, the researcher wants to know *what you think and believe* about inquiry-based instruction in Physical Sciences teaching.

1. DEMOGRAPHIC INFORMATION

1.1 Name of teacher: ……………………………………………………………………………

1.2 Circuit Management Centre (CMC): …………………………………………………………

1.3 Gender: [Male] [Female]

1.4 Historical Racial Group: [Black African] [Indian] [White] [Coloured]

1.5 Highest Teaching Qualification: ………………………………………………………….

1.6 Years of teaching:

……………………………………………………………………………...

1.7 What Physical sciences grades do you currently teach? [10] [11] [12]

1.8 How would you classify the community in which your school is located?

[Urban] [Suburban] [Township] [Rural]

1.9 What is the racial composition of your school?

……………………………………………

2. TEACHER BELIEFS

Think about your Physical Sciences teaching in one science class and respond to the following questions.

2.1 Briefly describe the role (s) that you play or use when teaching physical sciences.

2.2 Briefly explain why you play or use those roles.

2.3 How do you maximize learning when teaching physical sciences to your learners?

2.4 Briefly describe the role (s) that your learners play when learning physical sciences. How do you know when learners learn physical sciences best?

2.5 How do you know when learning is occurring during your physical sciences lessons?

2.6 How do you know when learners understand the physical sciences concept(s) during the lessons?

THANK YOU FOR PARTICIPATING IN COMPLETING THIS QUESTIONNAIRE

APPENDIX 2D:

SAMPLE OF STIMULATED RECALL INTERVIEW (SRI)

Thank you very much for participating in my project. The main focus of our interview today is to explore your beliefs and goals about teaching physical sciences through IBI. There are no wrong answers to any of the questions. Everything you tell me here is strictly confidential, and you can stop this interview at any point.

1. Based on your teaching experience:

- What are the things that excite you most about physical sciences teaching?
- What is (are) the goal (s) of teaching physical sciences?
- Do you think your physical sciences teaching aligns with this (these) goal(s)
- How do you view your role as a physical science teacher?
- What do you think is the role of IBI in physical sciences teaching?

2. In the Pedagogy of Science Teaching Test (POSTT) questionnaire, you indicated an understanding of different instructions for teaching science, such as Didactive Direct, Active Direct and Inquiry (Guided and Open). You indicated that most of the time, you used……….. (what the novice physical sciences teacher indicated: Didactive Direct, Active Direct, Guided Inquiry and Open Inquiry)

- Why did you decide on that instructional strategy?
- What do you desire your learners to be able to learn and do?

3. In the Teaching Goal Inventory (TGI), you indicated goals that are essential for you when teaching physical sciences, which are……. (name the goals)

- Why are these your essential goals?

4. For the lessons that I observed (the lesson's topic), you were (questions were based on teacher and learners' activities). Examples of questions from Amalia's lessons:

- What was your goal with this lesson?
- Why was it important for you to revise using questions from previous question papers?
- Why did you decide to do it that way?
- Do you think your goals for this lesson were realised? Why or why not?

5. In the other two lessons, practical investigation on (series and parallel connection motion on a trolley), you used PhET simulation for demonstration. You also gave them a worksheet to complete.

- What was your goal for using PhET simulations in these two activities?

- How could observing from PhET simulations help them achieve the learning objectives you aimed for?
- Were learning objectives achieved? Explain (how)
- Why do you think practical work is important for learning physical sciences?
- Where did you get the handouts (worksheets) you gave learners?
- What was your goal with these activities (PhET simulations)?
- Do you think your goals for this lesson were realised? Why or why not?
- How did you feel about that?

6. Can you tell me about some of the physical sciences lessons that I did not observe. Could you describe a lesson where you felt you were very effective?
- What makes you think that this was an effective lesson?
- What were the learners doing? How are these activities related to learning scientific ideas?
- How were your learners interacting with each other? With you?

7. Could you describe a lesson when you felt you were not very effective? Why do you think you were not very effective?

8. How do you want your learners to view physical sciences by the end of their school year?
- What are the most important factors that influence the way you teach?
- What are some examples of this? At the school level? At the Departmental level (SES)?

9. Can you describe to me the process through which you plan your lessons.
- What are the considerations you have during planning?
- What documents have you found to be very helpful in planning your lessons?

10. Could you tell me how you evaluate or assess the lesson objectives?
- What are the considerations you have during this phase?

11. What tools and materials do you use most often in your classroom?

12. What are the things that excite you most about physical sciences teaching?

13. Is there anything (additional) that you would like to add that was not covered in this interview?

THANK YOU FOR PARTICIPATING.

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